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Exploratory Studies of the Cruise Performance of Upper Surface Blown Configurations

Experimental Program - High-Speed Pressure Tests

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FOREWORD

This document is submitted in accordance with the requirements of NASA Contract NAS1-13871, Exploratory Studies of the Cruise Performance of Upper Surface Blown Configurations. W. C. Sleeman, Jr. is the NASA-Langley Contract Monitor and J. A. Braden is the Lockheed-Georgia Project Manager.

The technical results under this contract are presented in five reports. For convenience, the overall program documentation is summarized below:

DOCUMENTATION SUMMARY

CR Number	<u>Title</u>
CR-3193	Summary Report
CR-3192	Experimental Program - Test Facilities, Model Design, Instrumentation, and Low-Speed, High-Lift Tests
CR-159134	Experimental Program - High-Speed Force Tests
CR-159135	Experimental Program - High-Speed Pressure Tests
CR-159136	Program Analysis and Conclusions

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SUMMARY

The purpose and scope of the Cruise Performance Data Base Contract (NAS1-13871) are reviewed briefly in Section 1 of this document. Pertinent model and installation details are then described briefly. Objectives of the pressure test are discussed and the run schedule is outlined. Data are presented for both the standard type of nozzle installation fed by the wing duct and the upstream pipe test arrangement. The purpose of the latter was to permit testing of nacelles mounted on thin pylons on nacelles with nozzles too large for the wing duct supply. Additional variations in nacelle geometry covered by the data of this report are nacelle chordwise position and nozzle shape. Data for both straight and swept wing installations are included. Nacelle and wing pressures in both scrubbed and unscrubbed areas are presented. Wake isobars from data measured one chord length downstream of the wing trailing edge are presented for a number of the test configurations.

1.0 INTRODUCTION

In early 1975, the NASA awarded a contract (NAS1-13871) to the Lockheed-Georgia Company for the acquisition of a high-speed, experimental data base for aircraft configurations featuring nacelles mounted on the upper wing surface. This design concept, known as USB (upper-surface blowing), had received earlier, experimental endorsements as a viable means of achieving moderate-to-good powered lift performance along with beneficial noise reduction in the STOL environment. In the interest of further development of the USB-system, the contractual work performed by the Lockheed-Georgia Company emphasizes an exploratory investigation of the transonic cruise characteristics of USB nacelle-wing combinations. The total program is detailed in the Program Plan of Reference 1. Included in this Program Plan is the commitment to perform two-dimensional pressure tests of a selected range of wing/nacelle combinations. This effort is an important part of the Task II, Cruise Performance Data Base, which is described in Reference 1. To properly analyze the performance trends obtained in the force tests, local pressures on the nacelle and wing surfaces are required. In addition, wake total pressure patterns downstream of the model are also useful. It is to meet these needs as well as the pressure test requirements delineated in Task II that the data in this report are provided.

١

2.0 SYMBOLS

Dimensional data are presented herein in both the International System of Units (SI) and the U.S. Customary Units. The measurements and calculations were made in the U.S. Customary Units.

Α .	area, cm^2 (in. 2)
AR	aspect ratio
b	model spanz cm (in.)
BL	abbreviation: boundary layer
c, C	local wing chord, cm (in.)
ē	mean aerodynamic chord, cm (in.)
C _p , CP	pressure coefficient, $(p_l - p_{\infty})/q_{\infty}$
H _I /H _w , HL/HO	jet wake local total pressure ratio
M _∞ , M	freestream Mach number
P _∞	freestream static pressure, N/m^2 (lb/ft ²)
q	freestream dynamic pressure, N/m ² (lb/ft ²)
R _{NC}	Reynolds number based on ē.
x, X	distance parallel to tunnel centerline, cm (in.)
y, Y	transverse (spanwise) distance, cm (in.)
z, Z	vertical distance, cm (in.)
α	angle of attack, degrees
η	percent semispan

Note: Symbols following commas were employed on computer plots only.

3.0 MODEL AND INSTRUMENTATION DETAILS

The basic objective of the model design effort was to develop a wing-nacelle arrangement which could accommodate a wide range of USB nozzle types for comparative evaluation. An arrangement for metering smooth-profile, high-pressure air to the nozzle entrance was considered necessary. Means for obtaining static pressure distribitions on key surface areas were also required.

3.1 Model Design

To accomplish the desired objectives, the high-speed test configurations were developed around two wing-body configurations with untapered wings swept 0 and 25 degrees. These basic test vehicles could be combined in build-up fashion with a series of nacelle fore-bodies to form a wide range of powered or unpowered configurations. The choice of piped-in nozzle supply air over a powered simulator was made for simplicity and economy. A smooth flow profile at the nozzle entry is ensured by a choke plate with 0.159 cm (1/16 in.) diameter holes evenly distributed over the plate. The substitution of nacelles with other configuration designs, as well as conversion to the clean wing configurations, is made possible by the build-up design of the nacelle pylon, and nozzle mounting block. A remote-controlled traversing wake rake is positioned one chord length downstream to provide for complete mapping of the model/jet wake pattern.

A front view of the 2-D pressure model configuration mounted in the tunnel is presented in Figure 1. As the model is viewed in this photograph, nozzle supply air is ducted in from the right-hand side, while pressure tubes are routed out the left-hand side. The traversing wake rake can be seen in the background. A complete description of the model test arrangement including design details of all the model components is contained in Reference 2, which is Volume IIA of this same report.

3.2 Pressure Instrumentation Details

A layout of the straight wing planform along with spanwise locations of the 5 rows of static pressure taps is presented in Figure 2. Row A is directly behind the nacelle and immersed

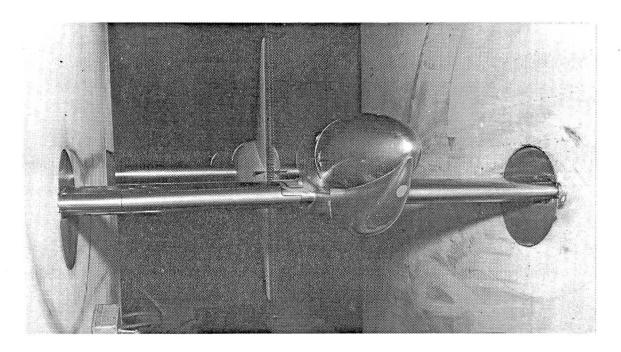


Figure 1. Two-dimensional pressure model and traversing wake rake mounted in CFF

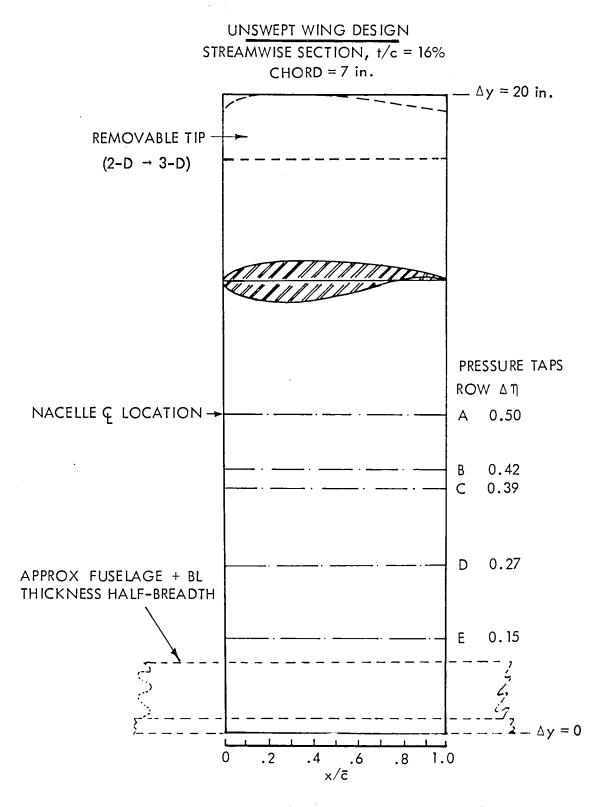


Figure 2. Straight wing planform and instrumentation layout

in the jet, while rows B and C are positioned to obtain jet and nacelle interference effects. Rows D and E are outside the wing/nacelle interference region. Figure 3 shows the chordwise positions for the pressure taps in each of the designated rows.

The planform for the swept wing is laid out in Figure 4 so that the corresponding information shown for the straight wing in Figure 2 is presented. Distribution of pressure tube rows is distinctly different from that carried out on the straight wing due to the provision for a dual nacelle arrangement. Rows A and A' are situated along the nacelle exhaust centerlines, while rows B and C' are between the two nacelles and between the inboard nacelle and the fuselage. Row C is just outboard of the outer engine. Chordwise positions for the pressure taps are presented in Figure 5.

The nozzles are instrumented with static pressure taps along their upper, outer centerlines. Locations of these surface orifices are provided in Figure 6. Nozzles designated with "E" subscripts have six pressure taps, while the standard, long nozzles have only five. In both cases the distributions are essentially linear except as dictated by hardware design constraints. Internal nozzle pressure instrumentation is detailed in Reference 2.

ROV	√ A ¹	ROV	/ В	ROV	/ C	ROWS D AND E	
UPPER	LOWER	UPPER	LOWER	UPPER	LOWER	UPPER LOWE	R
0.65		0.01	0.025	0.01	0.05	0.01 0.05	
0.70		0.02	0.050	0.02	0.20	0.05 0.20)
0.75		0.05	0.10	0.05	0.40	0.10 0.40)
0.80		0.10	0.20	0.10	0.60	0.15 0.60)
0.85		0.15	0.30	0.15	0.80	0.20 0.80	ı
0.90		0.20	0.40	0.20		0.30	
0.95		0.25	0.50	0.30		0.45	
1.00		0.30	0.60	0.40		0.55.	
		0.35	0.70	0.45		0.60	
		0.40	0.80	0.50		0.70	
		0.45	0.90	0.55		0.80	
		0.50		0.60		0.90	
		0.55		0.70		1.00	
		0.60		0.80			
		0,65		0.90			
		0.70		0.95			
		0.80		1.00			
		0.95					
		1.00					

Figure 3. Chordwise pressure tube locations for straight wing measured in x/c̄ from leading edge

SWEPT WING DESIGN, W₂

STREAMWISE SECTION, t/c = 14.5%
CHORD = 17.8cm (7.0 in.)

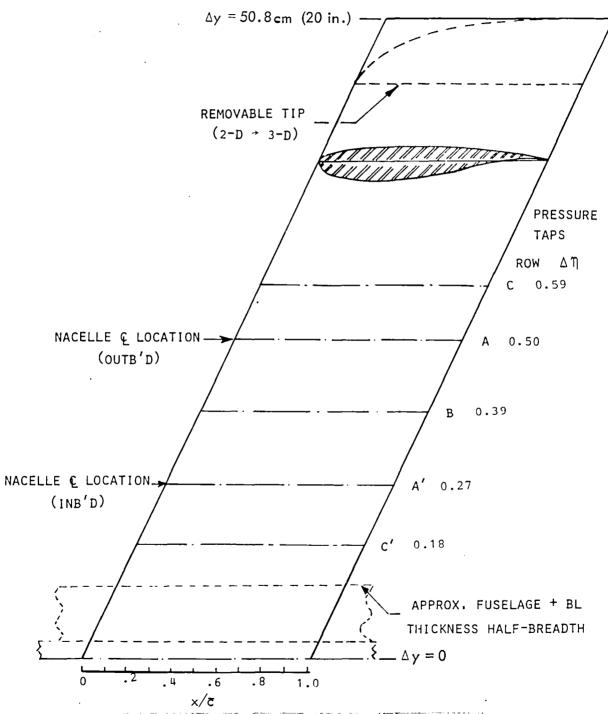


Figure 4. Swept wing planform and instrumentation layout

ROWS A AI	ND A'	ROWS B	AND B'	ROWS C A	ND C'
UPPER	LOWER	UPPER	LOWER	UPPER	LOWER
0.65		0.01	0.025	0.01	0.05
0.70		0.02	0.05	0.02	0.20
0.75		0.05	0.10	0.05	0.40
0.80		0.10	0.20	0.10	0.60
0.85		0.15	0.30	0.15	0.80
0.90		0.20	0.40	0.20	
0.95		0.25	0.50	0.30	
1.00		0.30	0.60	0.40	
	•	0.35	0.70	0.45	
		0.40	0.80	0.50	
		0.45	0.90	0.55	
		0.50		0.60	
		0.55		0.70	
•		0.60		0.80	
		0.65		0.90	
		0.70		0.95	
		0.80		1.00	
	•	0.90			
		0.95			
		1.00			

Figure 5. Chordwise pressure tube locations for swept wing measured in x/c̄ from leading edge

NEW NOZZIES, x/I	EXISTING NOZZLES, ×/I
0.186	0.369
0.353	0.479
0.559	0.582
0.745	0.699
0.932	0.807
-	0.903

- NOTES: (1) × IS DISTANCE MEASURED AFT FROM NACELLE JOINT.
 - (2) I IS NOZZLE LENGTH.
 - (3) EXISTING NOZZLES ARE DESIGNATED WITH "E" SUBSCRIPTS.

Figure 6. Nozzle pressure tube locations along nacelle upper surface

4.0 TEST DESCRIPTION

Both the pressure and force test phases of the USB Cruise Program were formulated around the use of minimum-cost, powered models in a porous-wall, blowndown test facility. This combination permitted a test program covering a comprehensive series of test configurations and parameter variations over an extensive range of test conditions. The test facility is described in detail in Reference 2.

4.1 Test Objectives

The primary objective of the pressure test program was to generate surface static pressure distributions in the jet along the wing surface and outside the jet in the critical interference regions around the nacelle-wing and jet-wing junctures. These would be used to analyze and explain various trends developed in the force test data analysis. They would also provide the means by which measured drag quantities could be broken down into their various components. A secondary objective of the pressure test was to obtain wake total pressure patterns downstream of the model test configurations.

4.2 Run Schedule Summary

The USB pressure tests were broken down into three separate programs — the straight wing with the short nozzle series (Test 07), the straight wing with the long nozzle series (Test 23), and the swept wing which was tested only with long nozzles (Test 22). Test 23 could be further broken down into those configurations which utilized the standard wing air—supply duct and those with air supplied by the upstream pipe. Reynolds numbers were held constant at 3.5 million to match the pressure tests and a porosity of 4% was maintained throughout the program. The entire pressure test program is summarized in Figure 7.

TEST	CONFIGURATION	CONFIGURATION	ŢE	ST	RUN	MACH NO.	ANGLE OF	NOZZLE PRES, RATIO,	
DESCRIPTION	DESCRIPTION	DEFINITION	NO.	SERIES	NOS.	M _∞	a ~ DEG	H./p	REMARKS
Pressure Surface	2-D Clean, Straight Wing	w, .	07	0	1 - 81	0.2 - 0.78	- 1 to 20		
Static + Wake Total	+ Circular Nacelle	W, B4 P7 C1 N2E	1	1	82 - 139	Static + 0.6 - 0.75	0 to 2	1.1 - 2.6	·
ļ ļ	+ Short D-Duct Nacelle	W1 B4 P7 C1 N3E		2	140 - 183	0.6 - 0.75	1 & 2	1.4 - 2.6	
1 1	+ AR 4 Nacelle	W, B, P, C, N, 4E		3	184 - 234	0.6 - 0.75	1 & 2	1.4 - 2.6	
	+ Short Circular Nacelle	W ₁ B ₄ P ₇ C ₁ N _{1E}		4	235 - 296	0.6 - 0.75	1 & 2,	1.0 - 4.0	Run Nos. 295 & 296 are Oil Flow
1	+ Short D-Duct Nacelle	W ₁ B ₄ P ₇ C ₁ N _{3E}		5	297 - 298	0.72	2	1.4 & 2.6	Oil Flow
1	+ AR 4 Nacelle	W, B, P, C, N4E		6	299 - 300	0.72	2	1.4 & 2.6	Oil Flow
. ↓	+ Circular Nacelle	W, B, P, C, N2E		7	301 - 302	0.72	2	1.4 & 2.6	Oil Flow
ļ <u> </u>	2-D Clean, Straight Wing	w ₁	*	8	303 - 325	0.6 - 0.78	0 to 3	,	R _{NC} from 3.0 to 12.0 x 10 ⁶
PressureSurface	2-D Clean, Straight Wing	W ₁	23	0	1 - 11	0,60 - 0.68	0 to 4		
Static + Wake Total	+ Short Pylon & Flo-Thru Nac.	W1 B1 P1 C5 N2	1	1	12 - 45	0.60 - 0.75	1 to 4		
	· Long D-Duct Nacelle	W ₁ B ₇ P ₈ C ₂ N ₃		2	46 - 149	Static + 0.6 - 0.72	1 to 4	1.0 - 4.0	
	· Long AR 6 Nacelle	W ₁ B ₇ P ₈ C ₂ N ₅		3	150 - 213	0.6 - 0.72	1 to 4	1.0 - 3.4	
}	Streamlined Nacelle	W1 B9 P12 C6 N6	1	4	214 - 302	Static + 0.6 - 0.72	I to 4	1.0 - 3.2	
	+ Short Pylon & Powered Nac	W, B, P, C, N,		5	303 - 409	Static + 0.6 - 0.72	2.6	1.0 - 3.0	Upstream Pipe Installed
	+ D-Duct Nac. at ×/c = 0.35	W1 B1 P11 C9 S6 N3	l	6	410 - 517	Static + 0.6 - 0.72	2.6	1.0 - 3.0	
	+ D-Duct Nac, at x/c = 0,50	W ₁ B ₁ P ₁₁ C ₉ S ₇ N ₃		7	518 - 624	Static + 0.6 - 0.72	2.6	1.0 - 3.0	
) }	+ D-Duct Nac. at x°c ≈ 0,20	W, B, P, C, S, N3		8	625 - 718	Static + 0.6 - 0.72	2.6	1.0 - 3.0	
	+ Large D-Duct Nac. at x ic = 0.35	W1 B1 P11 C8 S2 N1		9	719 - 801	Static + 0.6 - 0.72	2.6	1.0 - 3.0	
}	+ Large D-Duct Nac, at x c = 0.20	W, B, P, C, S, N,		10	802 - 886	Static + 0.6 - 0.72	2.6	1.0 - 3.0	
	+ Lorge D-Duct Nac. at x/c = 0.50	W1 B1 P11 C8 S3 N1	Y	11	887 - 958	Static + 0.6 - 0.72	2.6	1.0 - 3.0	
PressureSurface	2-D Clean, Swept Wing	W ₂	22	0	1 - 24	0.6 - 0.8	1 to 4		lst 327 Runs Bad
Static + Wake Total	+ Pylan Mounted Flo-Thru Nac.	W ₂ B ₂ P ₅ C ₅ N ₂	1	1	25 - 90	0.6 - 0.8	1 to 4	i	IST 327 KUNS BAG
	+ Outb'd D-Duct Nacelle	W ₂ B ₅ P ₉ C ₃ N ₈ 1		2	91 - 205	Static + 0.6 - 0.75	2 to 4	1.0 - 3.7	
	+ 2 D-Duct Nacelles	W ₂ B _{5,6} P _{9,10} C _{3,4} N ₈ ¹ N ₈ ²		3	206 - 430	Static + 0.6 - 0.75	2 to 4	1.0 - 3.5	
	+ Inb'd D-Duct Nocelle	W ₂ B ₅ P ₉ C ₃ N ₈		4	431 - 545	Static + 0.6 - 0.75	2 to 4	1.0 - 3.6	′
		, w ₂		5	546 - 571	0.6 - 0.8	1 to 4		
	- Flo-Thru Inlet + Circular Nac	W ₂ B ₂ P ₅ C ₅ N ₂		6	572 - 619	0.6 - 0.8	1 to 4		
†	• Small AR 6 Nacelle	W ₂ B ₅ P ₉ C ₃ N ₁₃	1	7	620 - 715	Static + 0.6 - 0.75	2 to 4	1.0 - 3.6	

NOTES: (1) $R_{NC} = 3.5 \times 10^6$, except where noted. (2) Wall parasity - 5% for force tests and 4% for pressure tests, except as noted.

Figure 7. Run schedule summary for pressure tests

5.0 STRAIGHT WING TEST RESULTS

The presentation of the straight wing pressure test results is divided into four parts, the first three of which are surface pressure distributions, while the last one is wake isobars in terms of local total pressure ratios. Pressure distributions are presented for the short nozzle test series, the long nozzle test series, and those configurations tested with the upstream pipe air supply.

5.1 Model Pressure Distributions, Short Nozzle Series

Data are presented for the first group of test nozzles in Figure 8 through 44. These consist of the so-called short nozzles, N_{1E} through N_{4E} . Because of their shortness, these nozzles have boattail angles which range from 17 to 36 degrees. Complete details of the model geometric characteristics are contained in Reference 2.

All data in this section are presented at a Reynolds' number of 3.5 million based on wing chord. In this section only, because of the many instances of overlapping, flags are used to denote lower surface pressure distributions. There are, of course, no lower surface pressure taps below the nozzle centerline.

CONFIG W
$$_1$$
 SYM TEST SERIES RUN M $_{\infty}$ α H $_j/p_{\infty}$ O 27 0.72 2 $^{\circ}$ -

CONFIG W1 B4 P7 C1 N3E

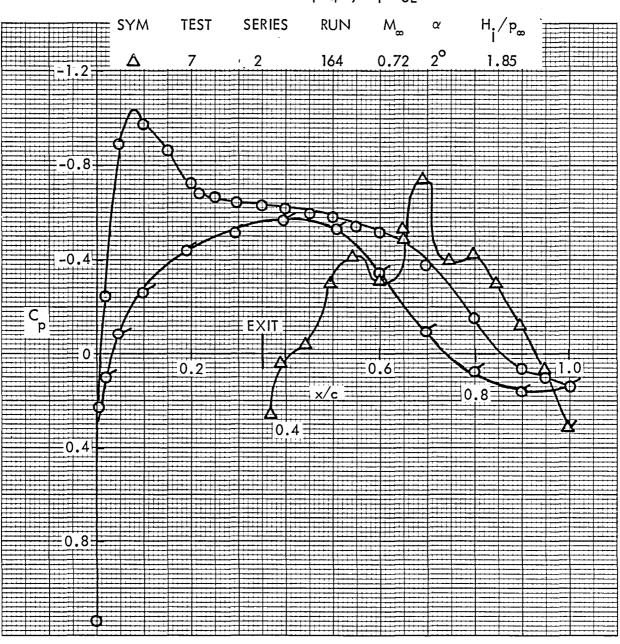


Figure 8. Wing pressure distribution, jet effect on wing pressures aft of nozzle compared to clean wing, $\eta = 0.50$

	•	CONFIG	W	1		
SYM	TEST	SERIES	RUN	M_{∞}	α	H _j /p _∞
0	7	0	27	0.72	2°.	-

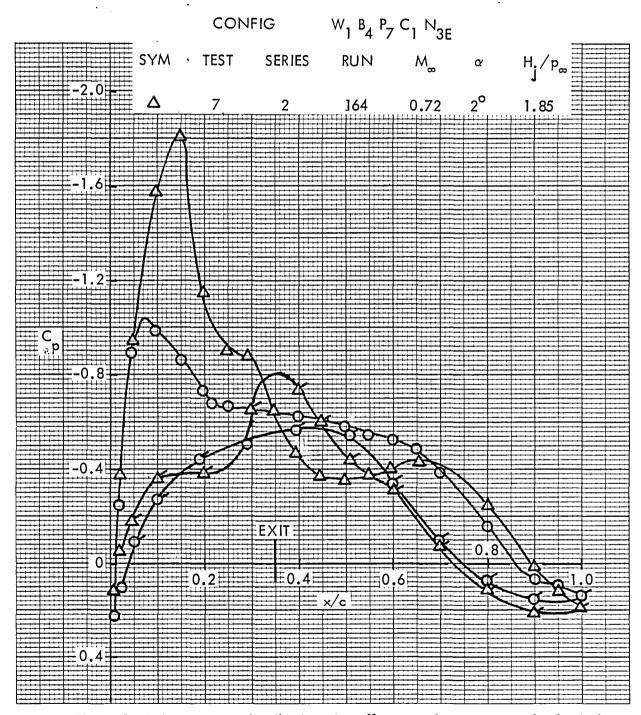


Figure 9. Wing pressure distribution, jet effect on wing pressures aft of nozzle compared to clean wing, η = 0.42

SYM
 TEST
 SERIES
 RUN

$$M_{\infty}$$
 α
 α
 $H_{\rm j}/P_{\alpha}$

 O
 7
 0
 27
 0.72
 2°
 -

 CONFIG
 W_1
 B_4
 P_7
 C_1
 N_{3E}

 SYM
 TEST
 SERIES
 RUN
 M_{∞}
 α
 $H_{\rm j}/P_{\rm o}$
 Δ
 7
 2
 164
 0.72
 2°
 1.85

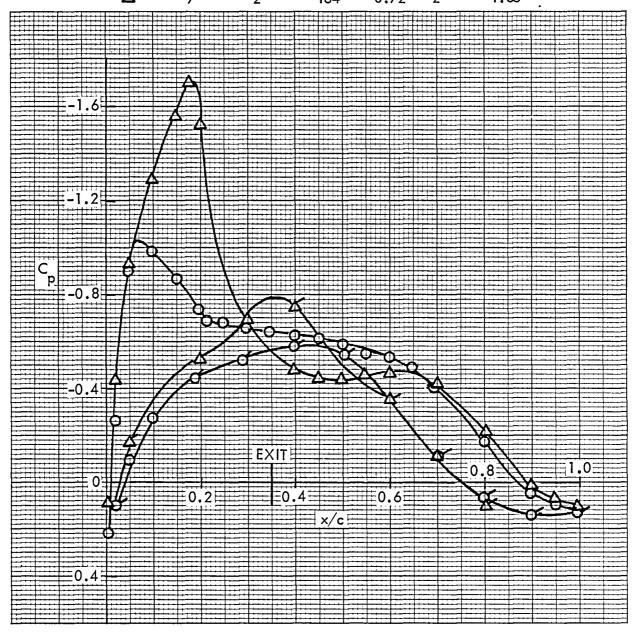


Figure 10. Wing pressure distribution, jet effect on wing pressures aft of nozzle compared to clean wing, $\eta = 0.39$

	CONFIG		W ₁ B ₄ P ₇	CINIE		
SYM	TEST	SERIES	RUN	$M_{_{\!$	α	H _j /p _∞
0	7	4	237	0.60	2°	2.62
Δ	7	4	293	0. <i>7</i> 5	2°	2.56

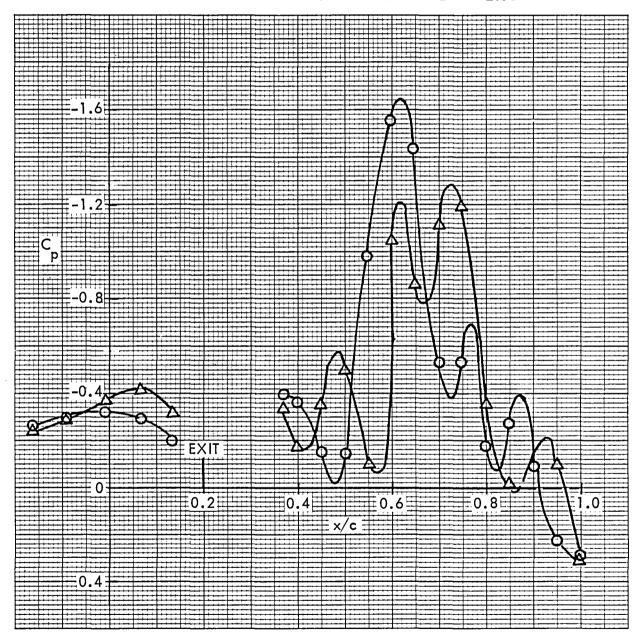


Figure 11. Wing pressure distribution, effect of Mach number, nozzle N_{1E} , $\eta = 0.50$

	CON	NFIG	W ₁ B ₄ P ₇ C ₁ N _{1E}			
SYM	TEST	SERIES	RUN	M_{∞}	α	H _j /p _∞
0	7	4	237	0.60	20	2.62
Δ	7	4	293	0.75	2°	2.56

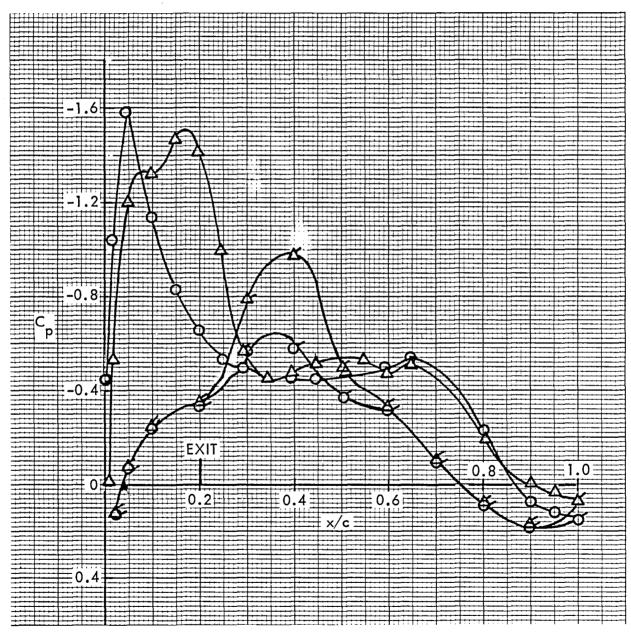


Figure 12. Wing pressure distribution, effect of Mach number, nozzle N_{1E} , $\eta = 0.42$

	CONFIG		W ₁ B ₄ P ₇ C ₁ N _{1E}			•	
SYM	TEST	SERIES	RUN	M _∞	α	H _j /p _∞	
0	7 ·	4	237	0.60	2°	2.62	
Δ	7	4	293	0.75	2°	2.56	

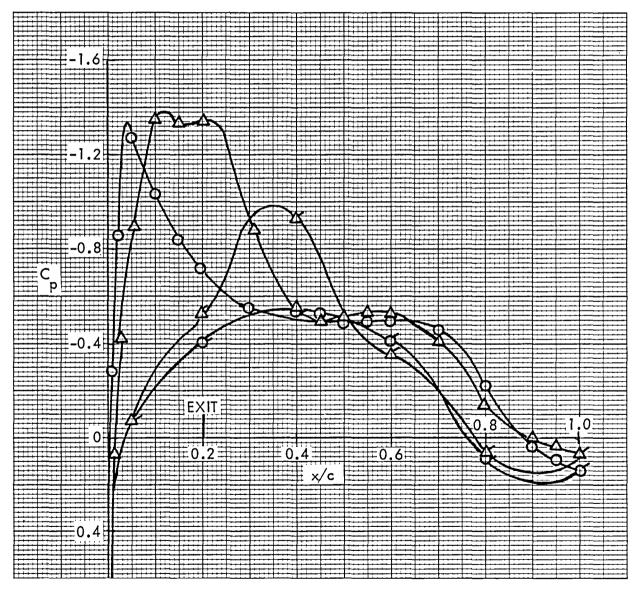


Figure 13. Wing pressure distribution, effect of Mach number, nozzle N_{1E} , $\eta = 0.39$

	CONFIG		W ₁ B ₄ P ₇	, C ₁ N _{2E}		
SYM	TEST	SERIES	RUN	M_{∞}	α	H./p _∞
0	7	1	128	0.60	2°	2.21
Δ	7	1	123	0.75	20	2.17

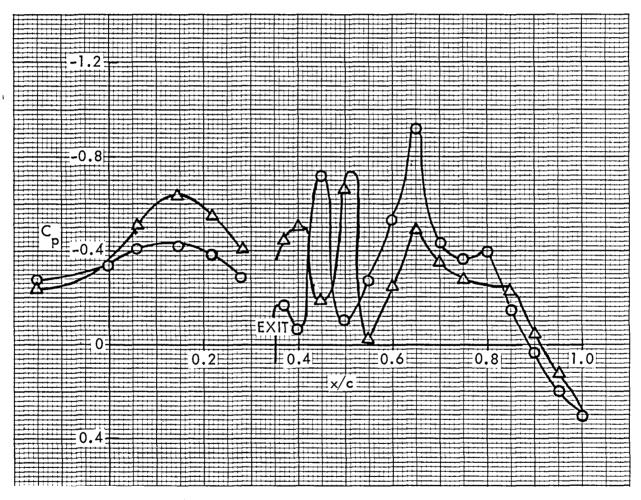


Figure 14. Wing pressure distribution, effect of Mach number, nozzle N_{2E} , $\eta = 0.50$

	CONFIG		$W_1 B_4 P$	7 C ₁ N ₂₁	•	
SYM	TEST	SERIES	RUN	M _{ee}	α	H./p _∞
0	7	1	128	0.60	2°	2.21
Δ	7	1	123	0.75	2°	2.17

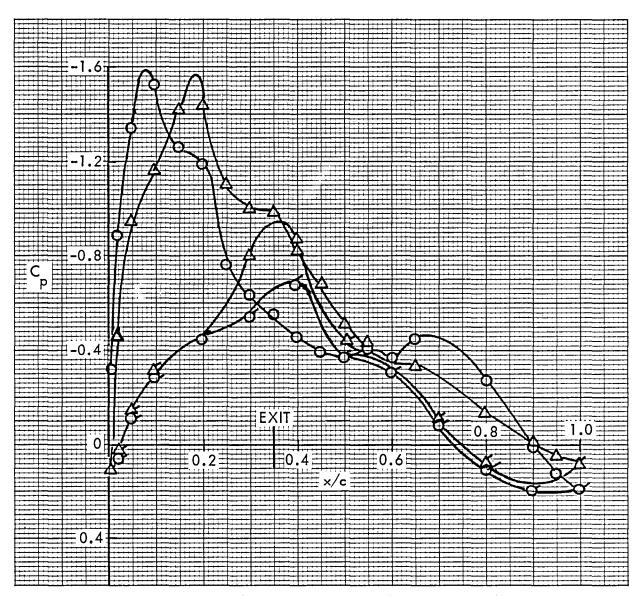


Figure 15. Wing pressure distribution, effect of Mach number, nozzle $N_{\rm 2E}$, η = 0.42

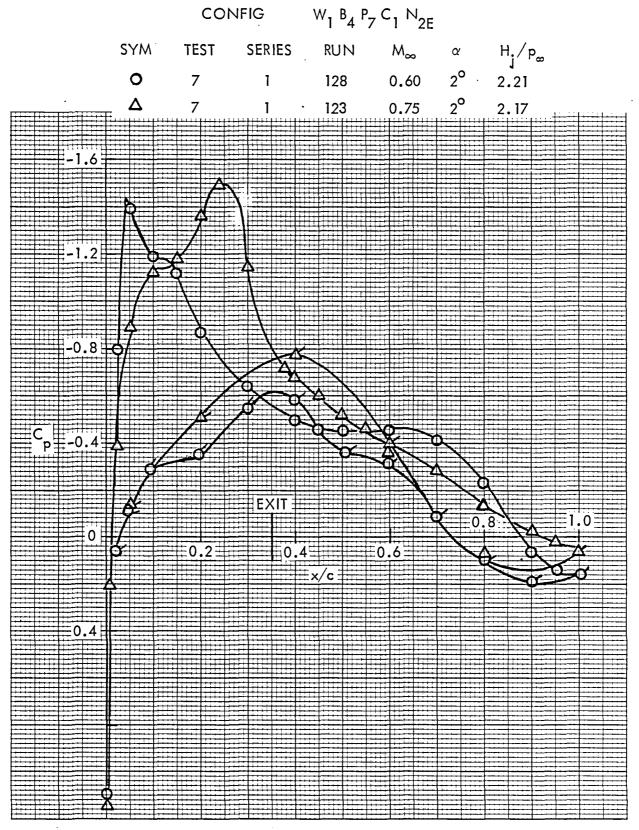


Figure 16. Wing pressure distribution, effect of Mach number, nozzle $N_{\rm 2E}$, η = 0.39

	CONFIG		W ₁ B ₄ P ₇ C ₁ N _{3E}			
SYM	TEST	SERIES	RUN	$M_{\mathtt{\varpi}}$	α	H. /p
0	7	2	144	0.60	2°	2.21
Δ	7	2	155	0.75	20	2.23

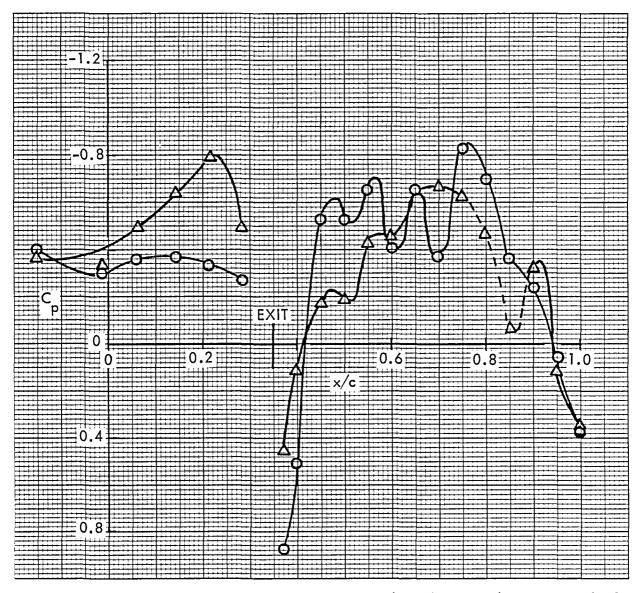


Figure 17. Wing pressure distribution, effect of Mach number, nozzle N_{3E} , η = 0.50

	CONFIG		W ₁ B ₄ P ₇ C ₁ N _{3E}			
SYM	TEST	SERIES	RUN	M _∞	α	H _j /P _∞
0	7	2	180	0.60	2°	1.78
Δ	7	2	155	0.75	20	2.23

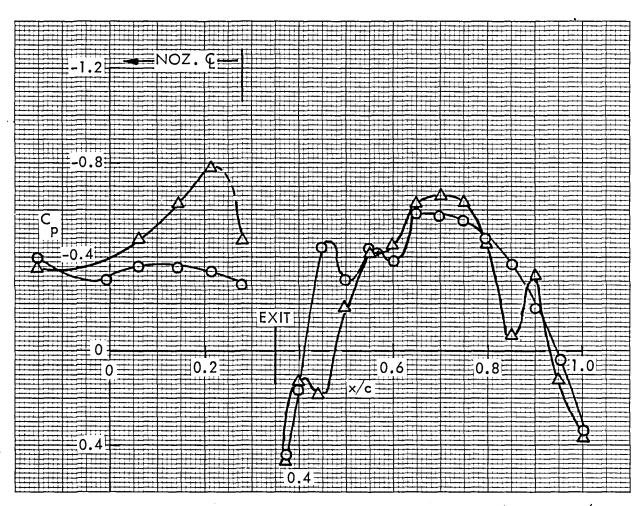


Figure 18. Wing pressure distribution, effect of Mach number, nozzle N_{3E} , q_j/q_{∞} = constant, η = 0.50

	CONFIG		W ₁ B ₄ P ₇	C ₁ N _{3E}		
SYM	TEST	SERIES	RUN	M _∞	α	H _j /p _∞
0	7	2	144	0.60	2°	2.21
Δ	7	2	155	0.75	2°	2.23

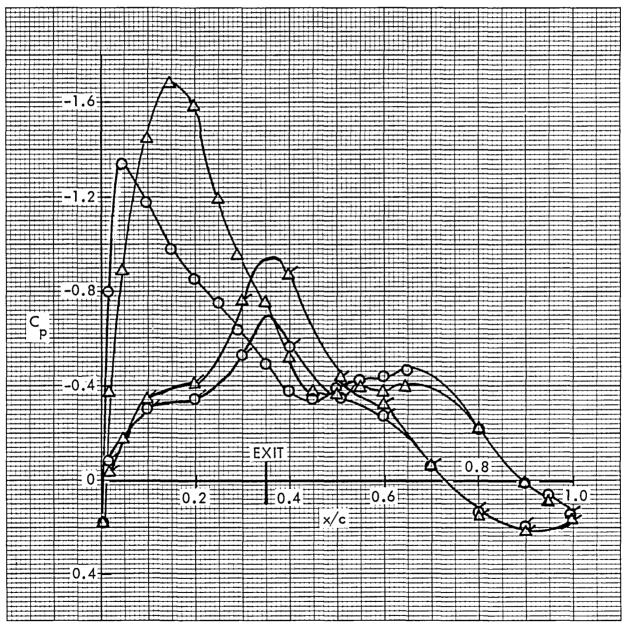


Figure 19. Wing pressure distribution, effect of Mach number, nozzle N_{3E} , η = 0.42

	CONFIG		W ₁ B ₄ P ₇	C ₁ N _{3E}		•
SYM	TEST	SERIES	RUN	M _∞	α	H./P _w
0	7	2	144	0.60	2°	2.21
Δ	7	2	155	0.75	2°	2.23

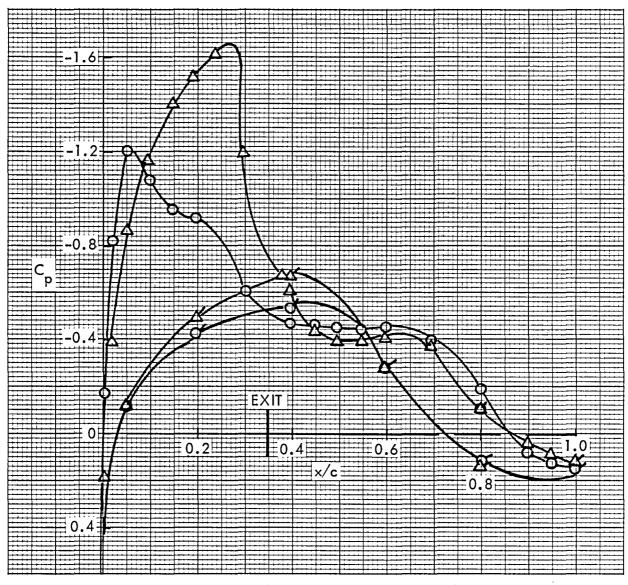


Figure 20. Wing pressure distribution, effect of Mach number, nozzle N_{3E} , η = 0.39

	CON	VFIG V	W ₁ B ₄ P ₇	C ₁ N _{4E}		
SŸM	TEST	SERIES	RUN	M _®	α.	H ₁ /P _∞
0	7	6	190	0.60	2°	2.21
Δ	7	6	215	0.75	2°	2.17

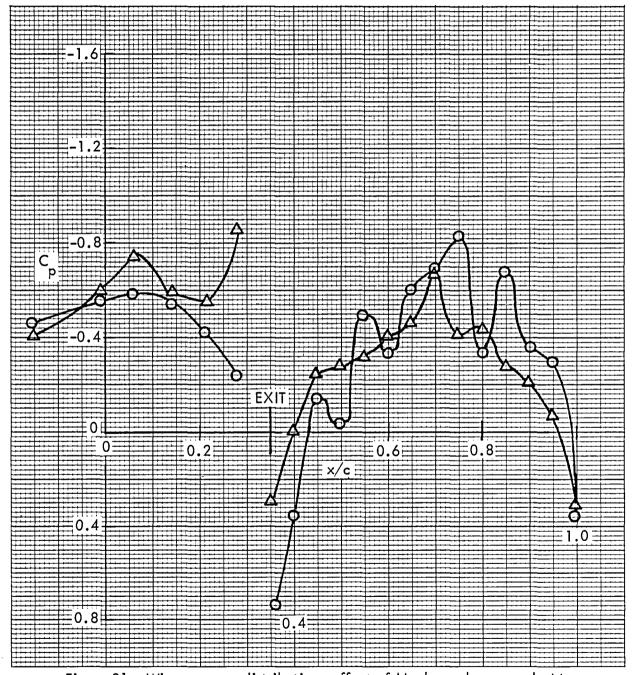


Figure 21. Wing pressure distribution, effect of Mach number, nozzle N_{4E} , η = 0.50

	CONFIG		W ₁ B ₄ P ₇	C ₁ N _{4E}		
SYM	TEST	SERIES	RUN	M _∞	α	H _j /p. _∞
0	7	6	190	0.60	2°	2.21
Δ	7	6	215	0.75	2°	2.17

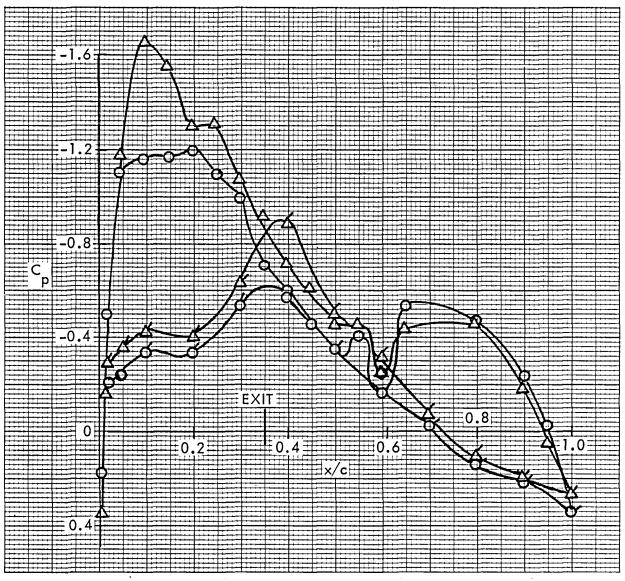


Figure 22. Wing pressure distribution, effect of Mach number, nozzle $N_{4E'}$ η = 0.42

	CO	NFIG	W1 B4 P7 C1 N4E				
SYM	TEST	SERIES	RUN	M_{∞}	α	H _j /p _∞	
0	7	6	190	0.60	2 ⁰	2.21	
Δ	7	6	215	0.75	20	2.17	

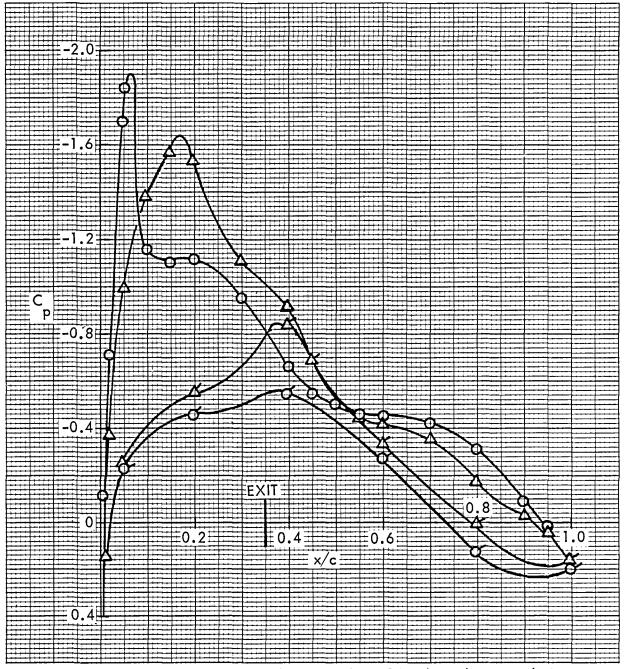


Figure 23. Wing pressure distribution, effect of Mach number, nozzle N_{4E} , $\eta = 0.39$

	CON	NFIG	W ₁ B ₄ P ₇ C ₁ N _{1E}				
SYM	TEST	SERIES	RUN	M _∞	α	H./p _∞	
0	7	4	284	0.72	2°	1.00	
Δ	7	4	275	0.72	2°	1.44	
+	7	4	282	0.72	2°	2.62	

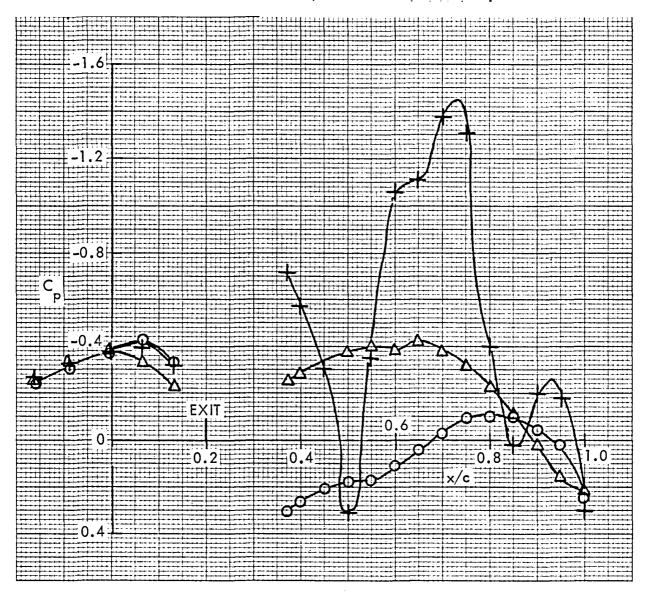


Figure 24. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N $_{1E}$, $\eta=0.50$

	CON	•				
SYM	TEST	SERIES	RUN	M_{∞}	α	H _j /p _∞
0	7	4	284	0.72	2°	1.00
Δ	7	4	275	0.72	2°	1.44
+	7	4	282	0.72	2°	2.62

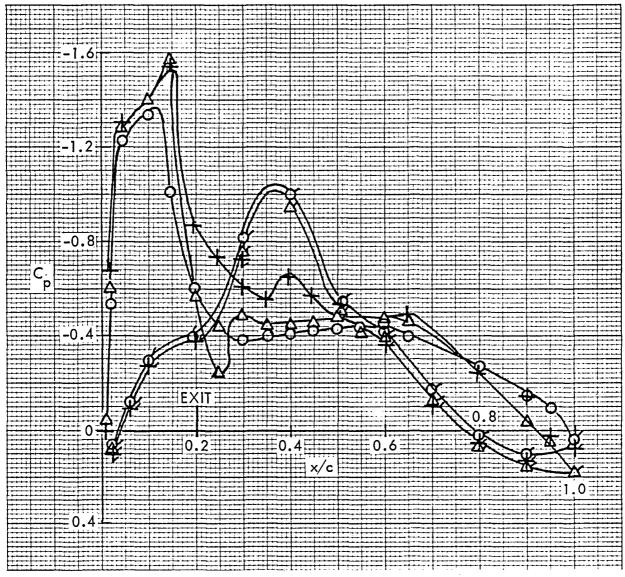


Figure 25. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N_{1E} , $\eta = 0.42$

	CON	NFIG	W ₁ B ₄ P ₇ C ₁ N _{1E}			
SYM	TEST	SERIES	RUN	M _∞	α	H. /p
0	7	4	284	0.72	2°	1.00
Δ	7	4	275	0.72	2°	1.44
+	7	4	282	0.72	20	2.62

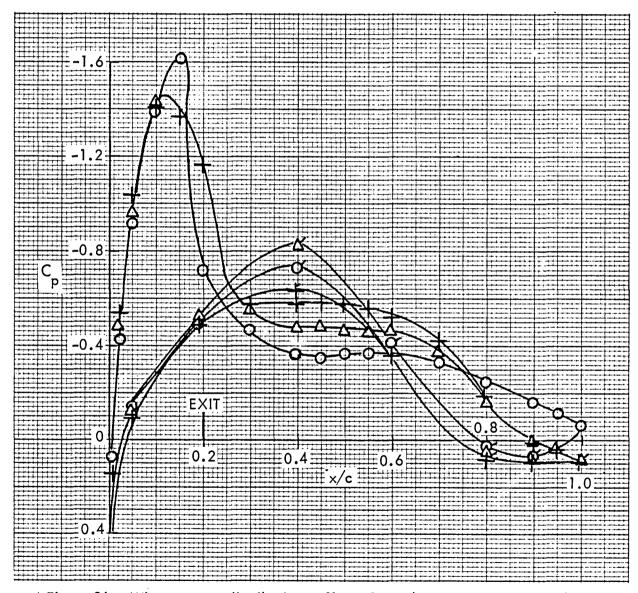


Figure 26. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N $_{1E}$, η = 0.39

•	. CO	NFIG	W ₁ B ₄ P ₇ C ₁ N _{2E}				
SYM .	TEST	SERIES	RUN	M _®	α	$^{\rm H_{\it j}/p_{\it \varpi}}$	
0	7	1	111	0.72	2°	1.44	
Δ	7	ī	112	0.72	2°	1.85	
+	7	1	132	0.72	20	2.65	

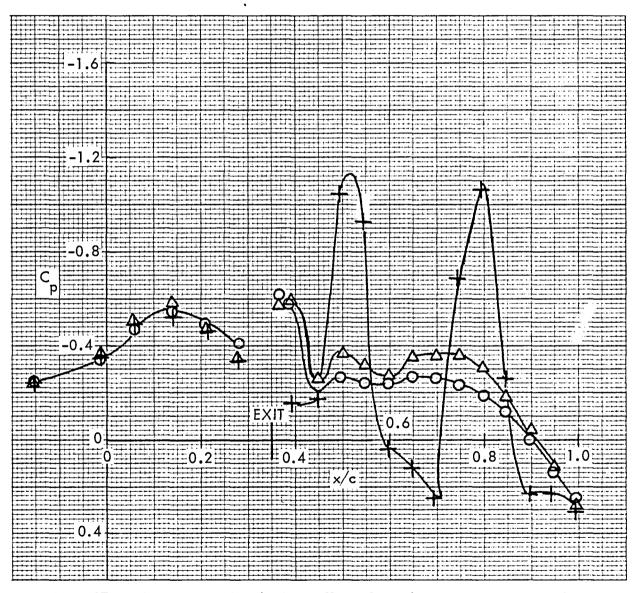


Figure 27. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N_{2E} , η = 0.50

	COI	VFIG	W ₁ B ₄ P ₇ C ₁ N _{2E}				
SYM	TEST	SERIES	RUN	M _®	α	H./p _∞	
0	7	1	111	0.72	2°	144	
Δ	7	1	132	0.72	2°	2.65	

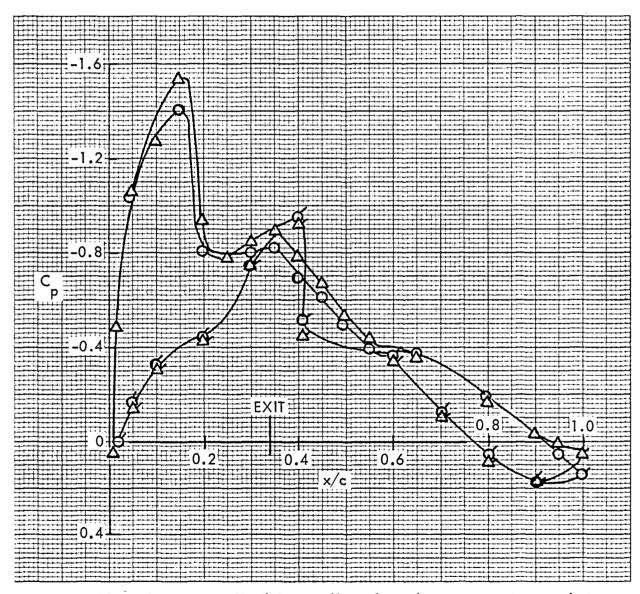


Figure 28. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N_{2E} , η = 0.42

	CON	VFIG	W ₁ B ₄ P ₇ C ₁ N _{2E}				
SYM	TEST	SERIES	RUN	M_{∞}	α	H_{j}/p_{ω}	
0	7	1	111	0.72	2°	1.44	
Δ	7	1	132	0.72	2°	2.65	

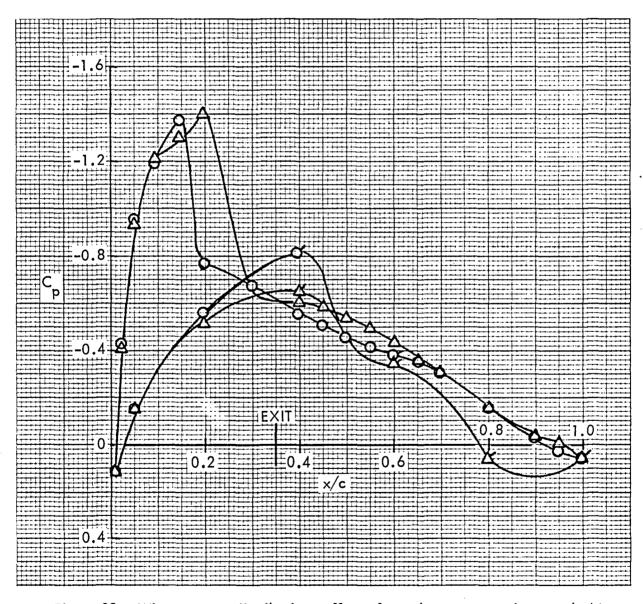


Figure 29. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N $_{\rm 2E}$, η = 0.39

	CON	1FIG	W ₁ B ₄ P ₇ C ₁ N _{3E}			
SYM	TEST	SERIES	RUN	M _∞	α	H _j /p _∞
0	7	2	167	0.72	2°	1.44
Δ	7	2	164	0.72	2°	1.85
+	7	2	140	0.72	2°	2.70

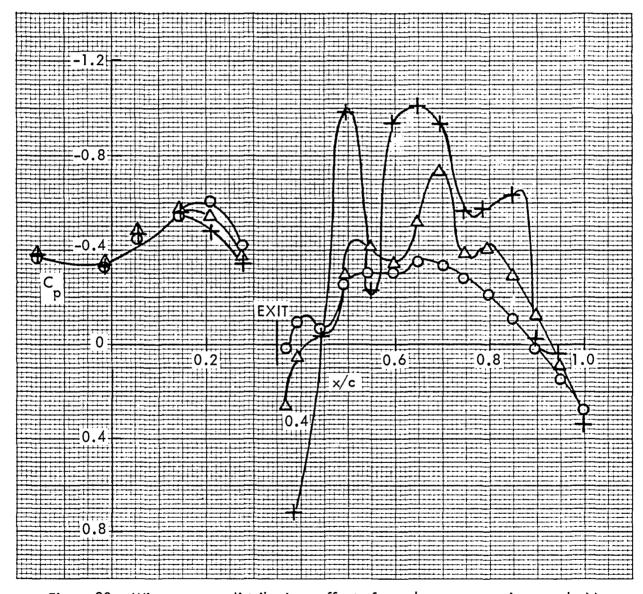


Figure 30. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N_{3E} , η = 0.50

	CO	NFIG-	W, B4 P7 C1 N3E			•	
SYM	TEST	SERIES	RUN	, M _®	α	H, /p _∞	
0	7	2	167	0.72	2°	1.44	
Δ	7	2	140	0.72	2°	2.70	

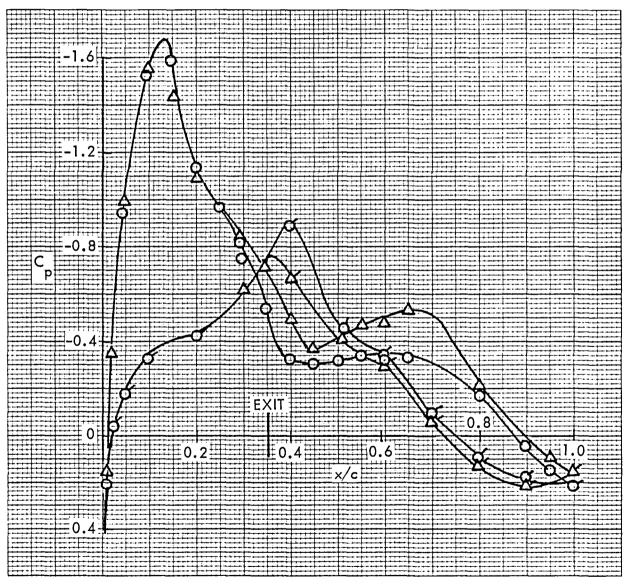


Figure 31. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N_{3E} , $\eta=0.42$

	CONFIG W1 B4 P7 C1 N3E						
SYM	TEST	SERIES	RUN	M _∞	α		$H_{\mathbf{j}}/P_{\infty}$
0	7	2	167	0.72	20	•	1.44
Δ.	7	2	140	0.72	20		2.70

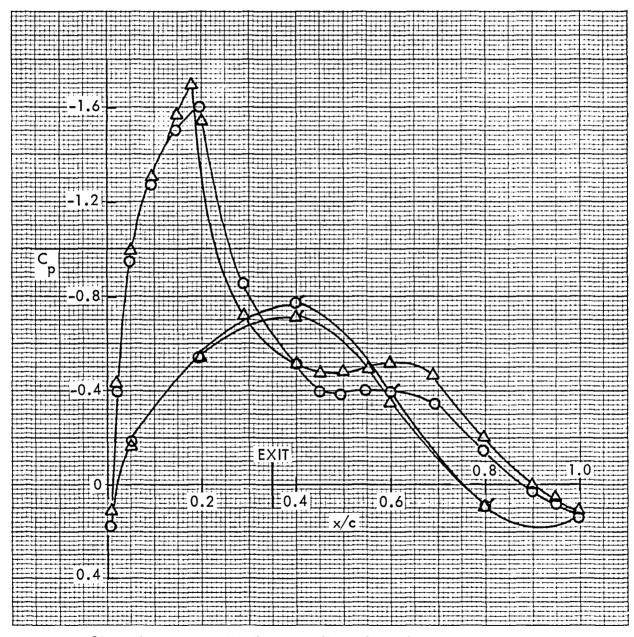


Figure 32. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N_{3E} , $\eta = 0.39$

CONFIG	W ₁ B ₄	P ₇ C	N _{4E}
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SYM	TEST	SERIES	RUN	M_{∞}	α	H_{j}/p_{ω}
0	7	3	202	0.72	2°	1.44
Δ	7	3	205	0.72	2°	1.83
	_	•	00.4	0.70	20	2 45

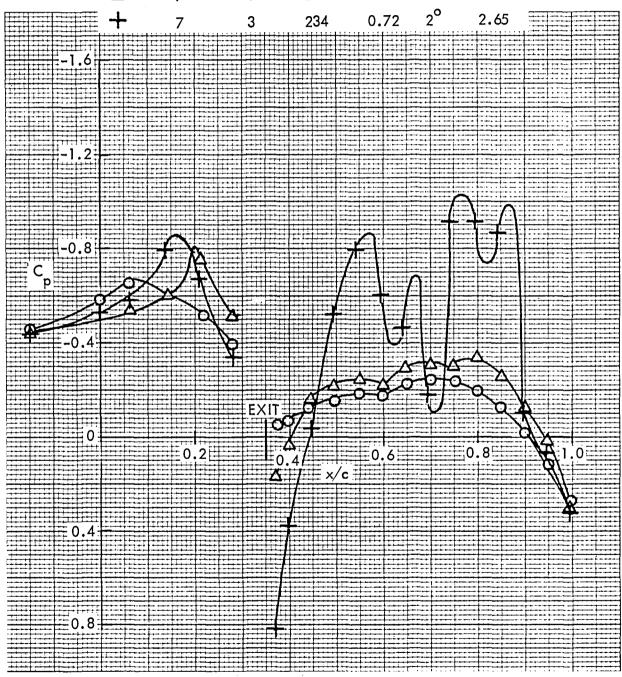


Figure 33. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N_{4E} , $\eta = 0.50$

CONFIG
$$W_1 B_4 P_7 C_1 N_{4E}$$

SYM	TEST	SERIES	RUN	M _®	α	H _i /p _∞
		3				•
Δ	7	3	234	0.72	2°	2.65

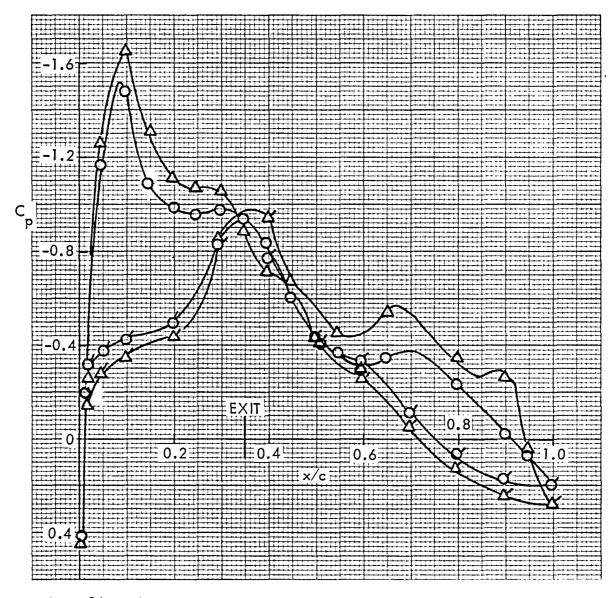


Figure 34. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N_{4E} , η = 0.42

	CON	1FIG	W ₁ B ₄ P ₇	W ₁ B ₄ P ₇ C ₁ N _{4E}			
SYM	TEST	SERIES	RUN	M _®	α	H _i /p _∞	
0	7	3	202	0.72	2°	1.44	
Δ	7	3	234	0.72	20	2.65	

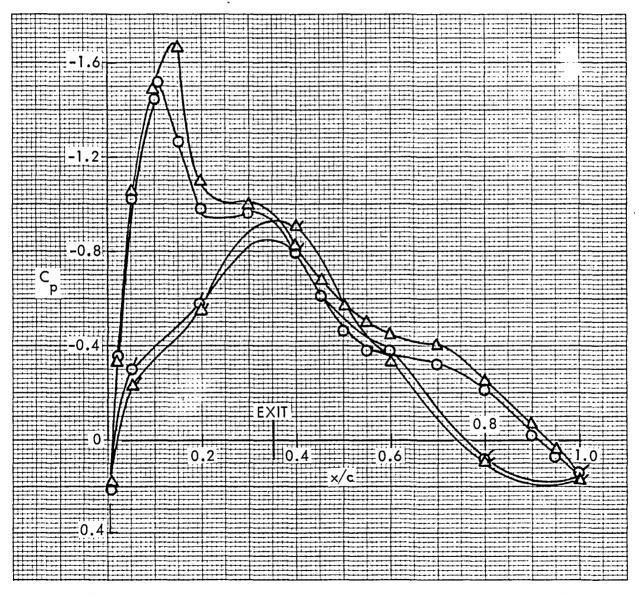


Figure 35. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N_{4E} , η = 0.39

	COI	VFIG	W ₁ B ₄ P ₇	$C_1 N_{4E}$			
SYM	TEST	SERIES	RUN	M_{∞}	α .	$\frac{H}{j}/p_{\varpi}$	
0	7	3	202	0.72	2°	1.44	
Δ	7	3	205	0.72	2°	1.83	
+	7	3	234	0.72	20	2.65	

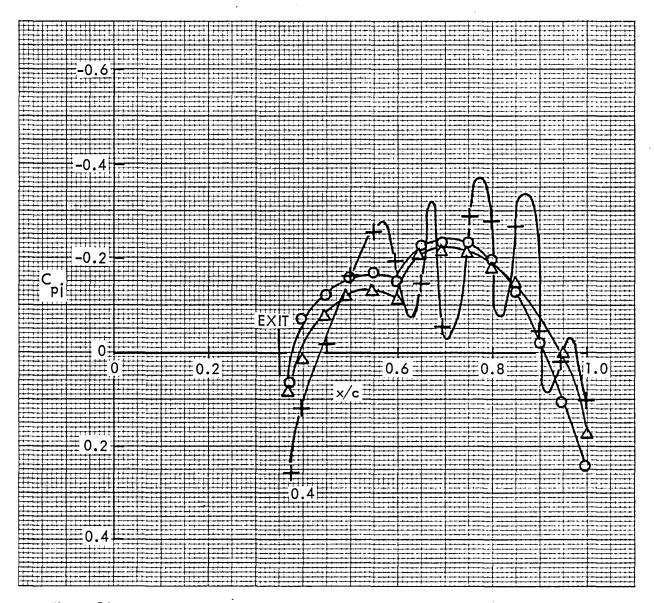


Figure 36. Wing pressure distribution based on q , effect of nozzle pressure ratio, nozzle N_{4E} , $\eta=0.50$

	CON	1FIG	W ₁ B ₄ P ₇			
SYM	TEST	SERIES	RUN	M _∞	α	H _j /P _∞
0	7	1	11,1	0.72	2°	1.44
Δ	7	1	112	0.72	2°	1.85
+	7	1	132	0.72	2°	2.65

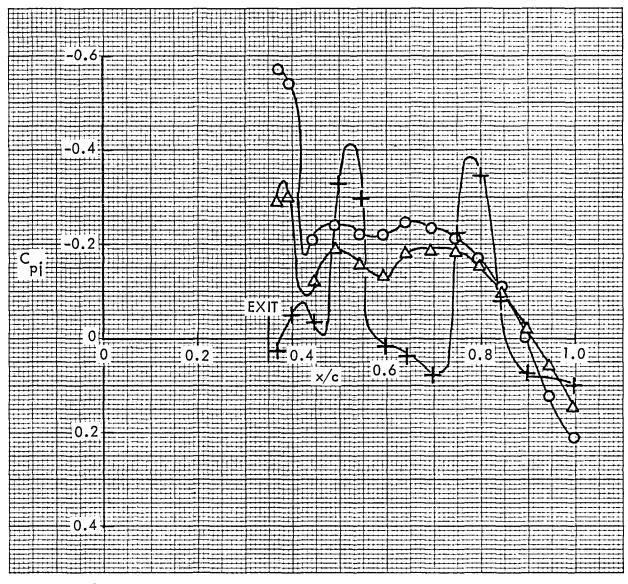


Figure 37. Wing pressure distribution based on q , effect of nozzle pressure ratio, nozzle N_{2E} , η = 0.50

CONFIG	SYM	TEST	SERIES	RUN	$M_{\hat{\boldsymbol{\omega}}}$	α	H./p _∞
W ₁ B ₄ P ₇ C ₁ N _{2E}							•
W ₁ B ₄ P ₇ C ₁ N _{3E}		7		140			
W ₁ B ₄ P ₇ C ₁ N _{4E}		7	3	234	0.72	2°	2.65

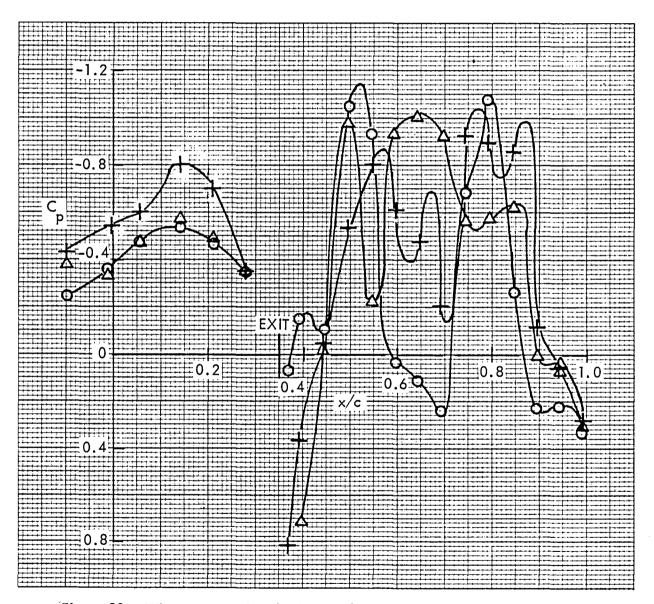


Figure 38. Wing pressure distribution, influence of nozzle shape, η = 0.50

CONFIG	SYM	TEST	SERIES	RUN	. M _∞	α	H _j / _{P∞}
W ₁ B ₄ P ₇ C N _{2E}	0	7	1	132	0.72	2°	2.65
W ₁ B ₄ P ₇ C ₁ N _{3E}	Δ		2				
W ₁ 'B ₄ P ₇ C ₁ N _{4E}		7	3	234	0.72	2°	2.65

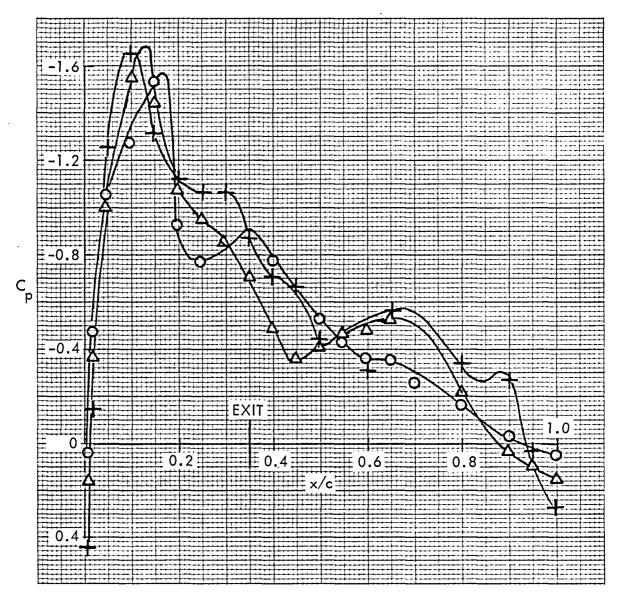


Figure 39. Wing pressure distribution, influence of nozzle shape, η = 0.42

CONFIG	SYM	TEST	SERIES	RUN	M _∞	α	H.∕p _∞
W ₁ B ₄ P ₇ C ₁ N _{2E}	0	7	1	132	0.72	2°	2.65
W ₁ B ₄ P ₇ C ₁ N _{3E}	Δ						
	+	7	3	234	0.72	2°	2.65

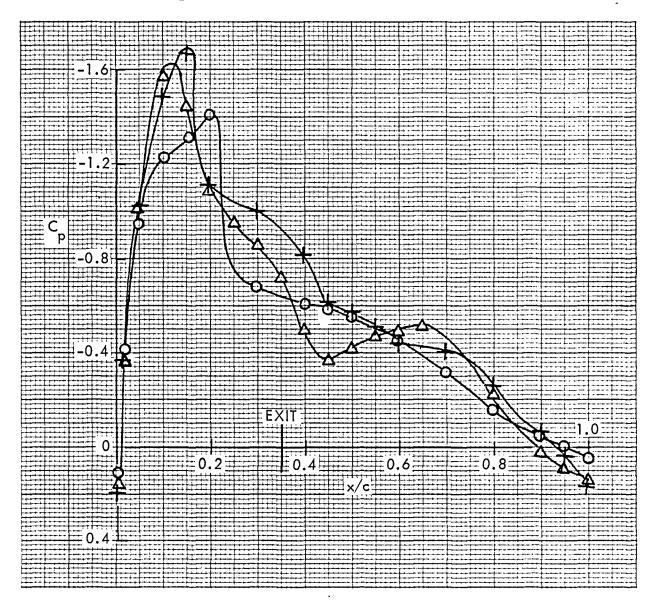


Figure 40. Wing pressure distribution, influence of nozzle shape, $\eta = 0.39$

CONFIG	SYM	TEST	SERIES	RUN	M_{∞}	α	H _j /p _∞
W ₁ B ₄ P ₇ C ₁ N _{2E}	0	7	1	111	0.72	2°	1.44
$W_{1}^{B_{4}} P_{7}^{P_{7}} C_{1}^{N_{3F}}$	_		-2				
W ₁ B ₄ P ₇ C ₁ N _{4E}			3				
W ₁ B ₄ P ₇ C ₁ N _{1E}	×	7	4	275	0.72	2°	1.44

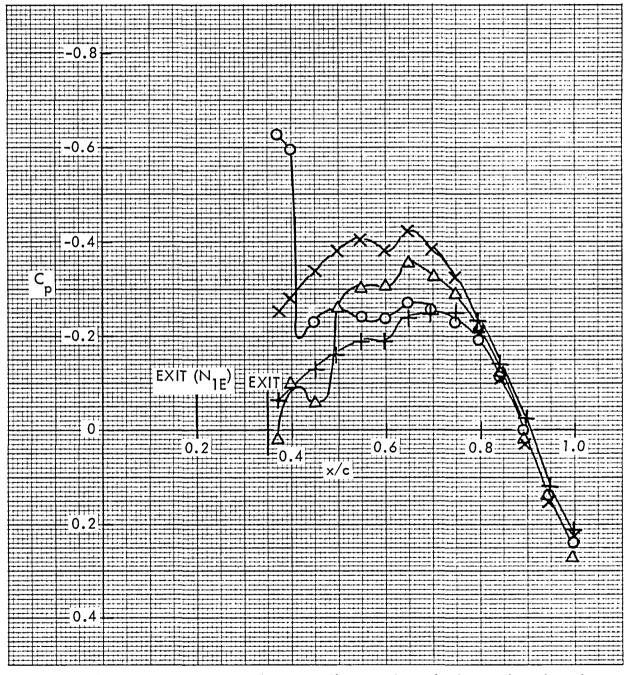


Figure 41. Wing pressure distribution, influence of nozzle shape, flow-through pressure ratio, $\eta = 0.50$

CONFIG
$$W_1 B_4 P_7 C_1 N_{2E}$$

TEST SERIES RUN $M_{\infty} \alpha H_j / P_{\infty}$

7 1 139 0.72 2° 2.60

SYM η

O 0.50

 Δ 0.42

 $+$ 0.39

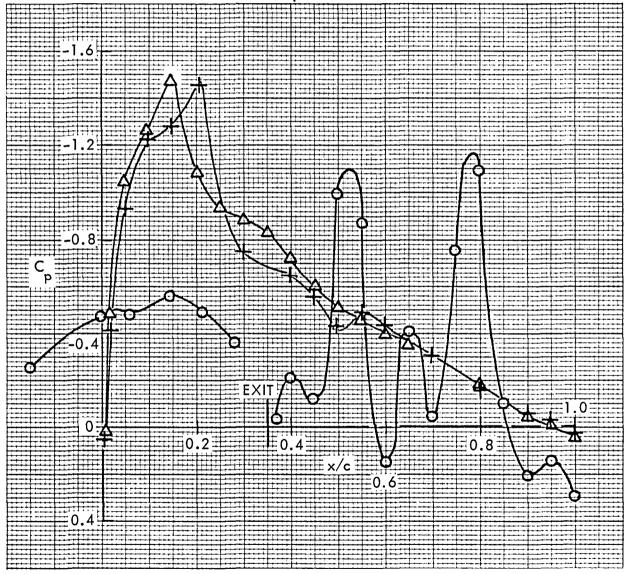


Figure 42. Wing pressure distribution, spanwise influence of jet, nozzle N_{2E}

CONFIG
$$W_1 B_4 P_7 C_1 N_{3E}$$

TEST SERIES RUN $M_{\infty} \alpha H_j / P_{\infty}$

7 1 140 0.72 2° 2.67

SYM η

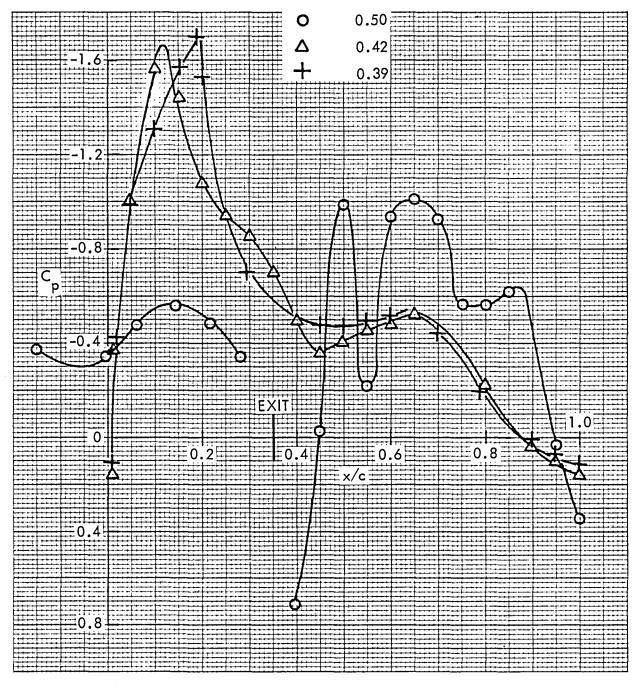


Figure-43. Wing pressure distribution, spanwise influence of jet, nozzle N_{3E}

CONFIG
$$W_1 B_4 P_7 C_1 N_{4E}$$

TEST SERIES RUN $M_{\infty} \alpha H_j / P_{\infty}$

7 3 210 0.72 2° 2.60

SYM η

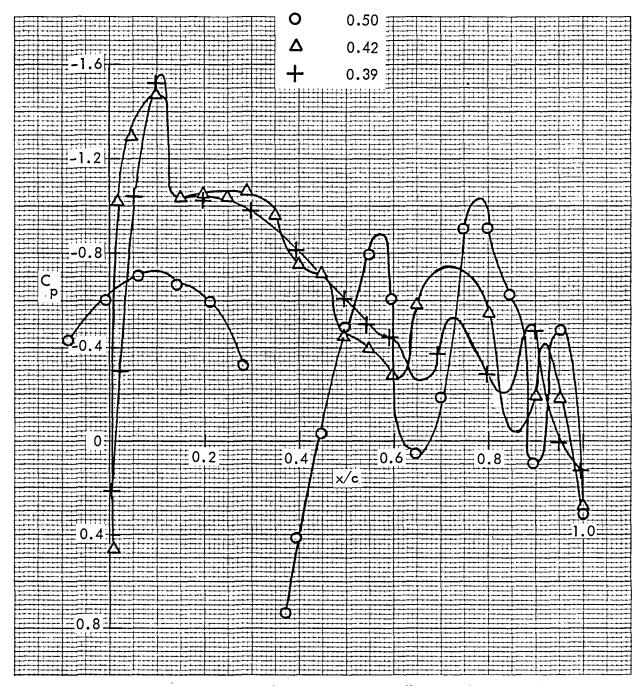


Figure 44. Wing pressure distribution, spanwise influence of jet, nozzle N_{4E}

5.2 Model Pressure Distributions, Long Nozzle Series

Surface static pressure data for the long nozzle series are presented in Figure 45 through 72. The format of presentation for these data is slightly different from that used for the short nozzle series. Two spanwise positions are presented per page as compared to one for the short nozzle series. Since data was taken at four spanwise positions for this group, two pages are required to show the data for each test run.

These data begin with the clean straight wing which is followed by the circular nozzle, N_2 , mounted in flow-through configuration on a short pylon. Data are then presented for nozzles N_3 , N_5 , and N_6 mounted in the standard USB configuration. These are the D-duct, AR = 6, and streamlined D-duct nacelles respectively. All data in this series are presented at a Reynolds' number of 3.5 million based on wing chord.

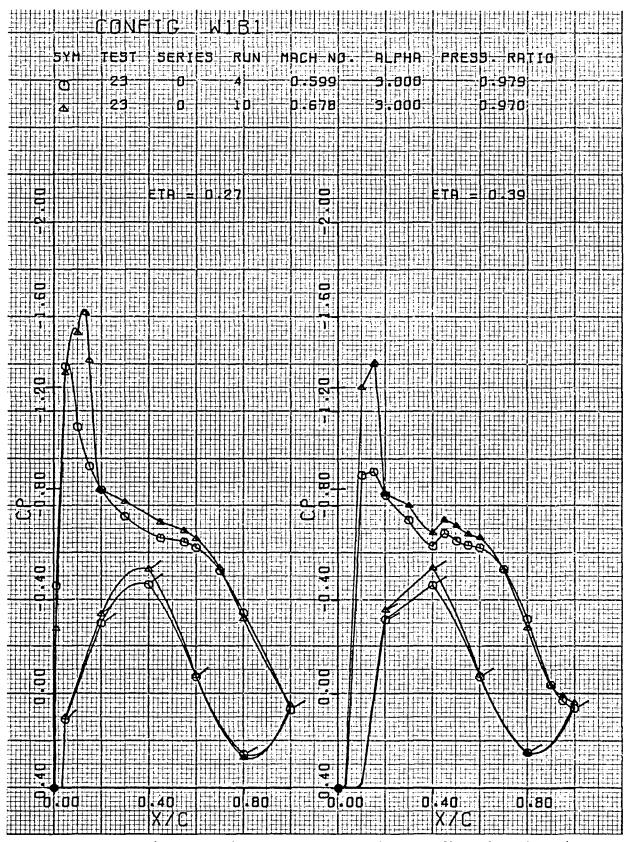


Figure 45. Clean, straight wing pressure distribution, effect of Mach number, $\eta = 0.27, 0.39$

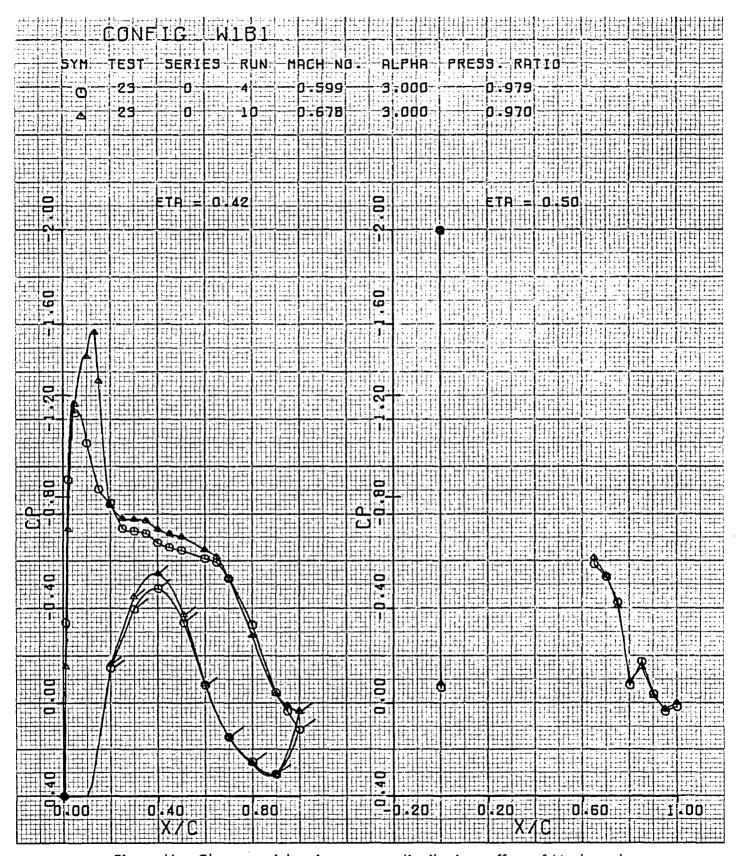


Figure 46. Clean, straight wing pressure distribution, effect of Mach number, η = 0.42, 0.50

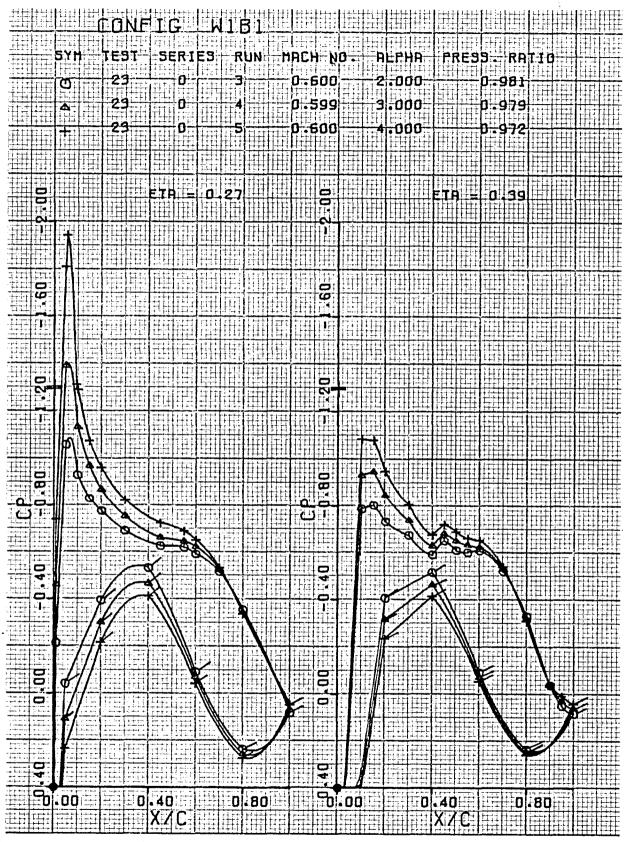


Figure 47. Clean, straight wing pressure distribution, effect of α , M_{∞} = 0.60, η = 0.27, 0.39

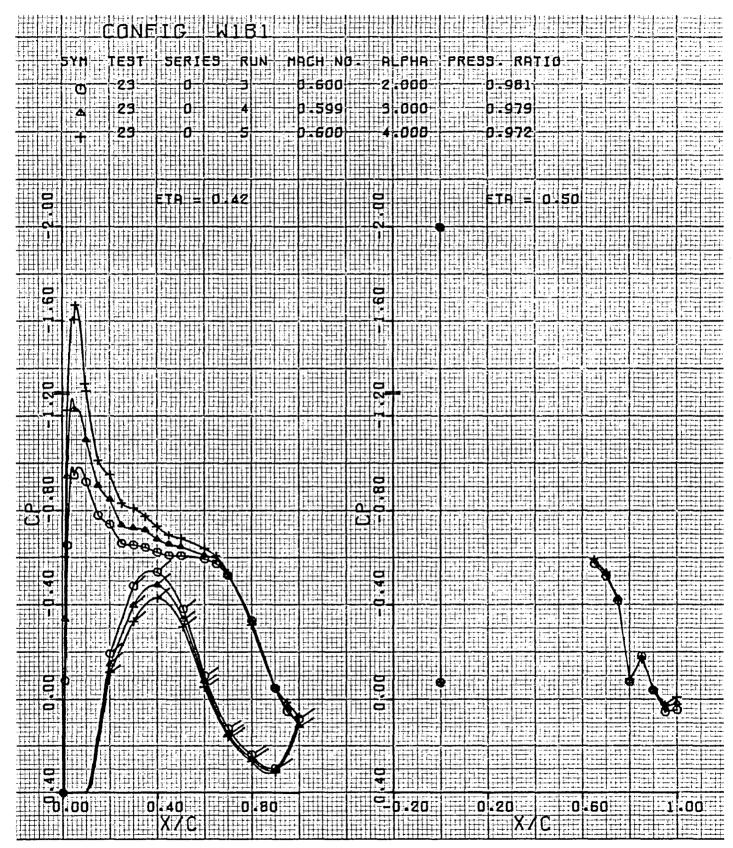


Figure 48. Clean, straight wing pressure distribution, effect of α , $M_{\infty}=0.60$, $\eta=0.42,\,0.50$

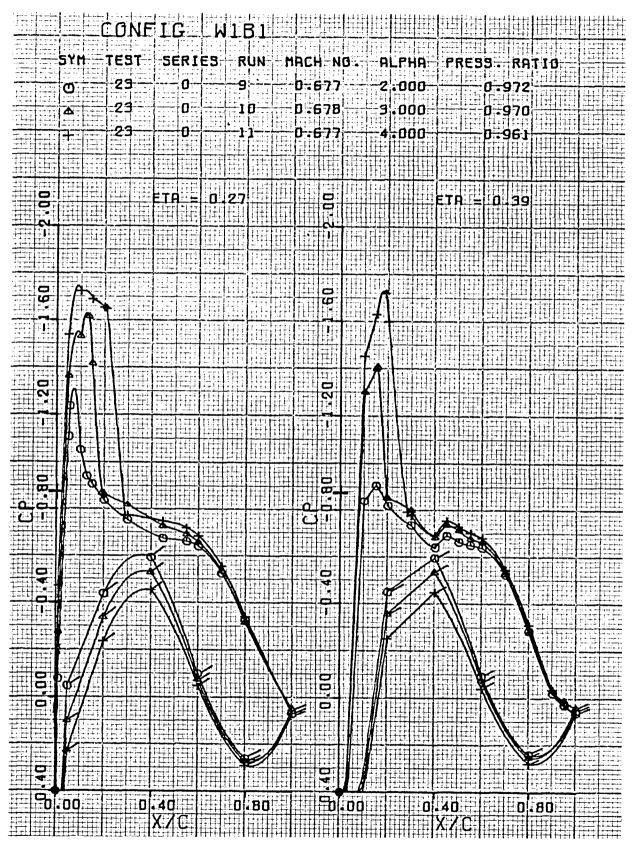


Figure 49. Clean, straight wing pressure distribution, effect of α , M_{∞} = 0.68, η = 0.27, 0.39

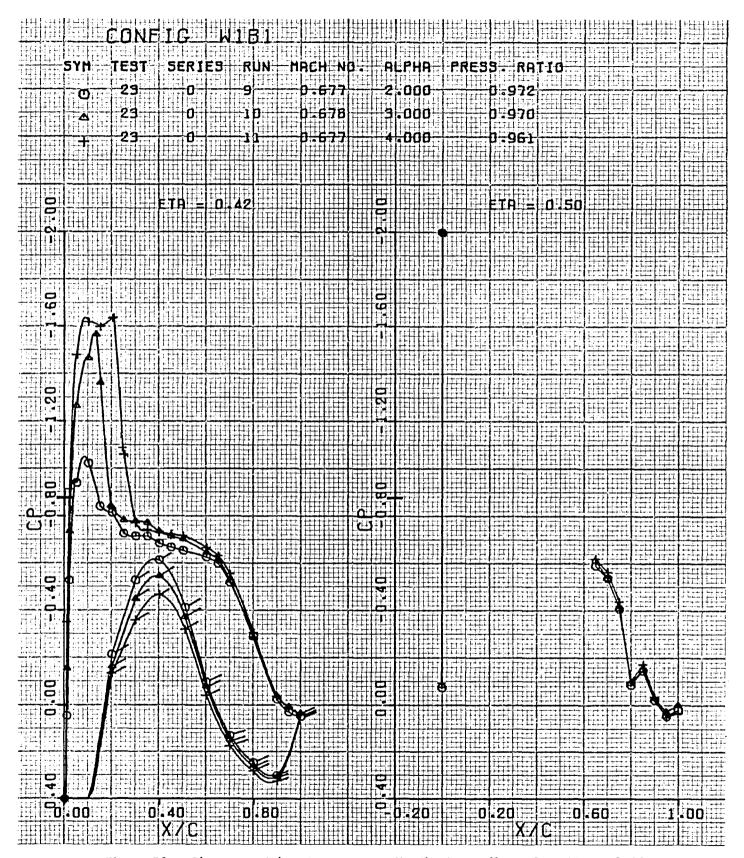


Figure 50. Clean, straight wing pressure distribution, effect of α , M_{∞} = 0.68, η = 0.42, 0.50

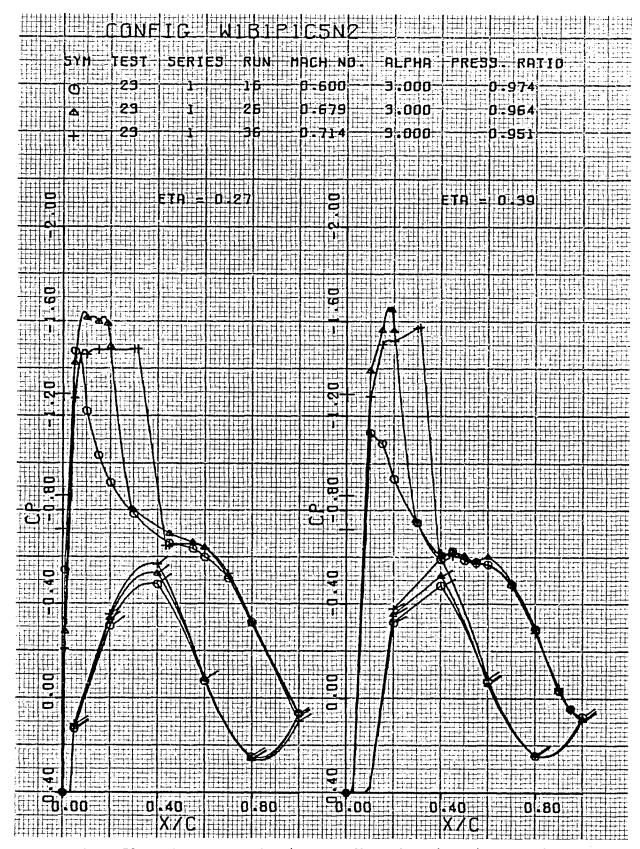


Figure 51. Wing pressure distribution, effect of Mach number, nozzle N_2 , η = 0.27, 0.39

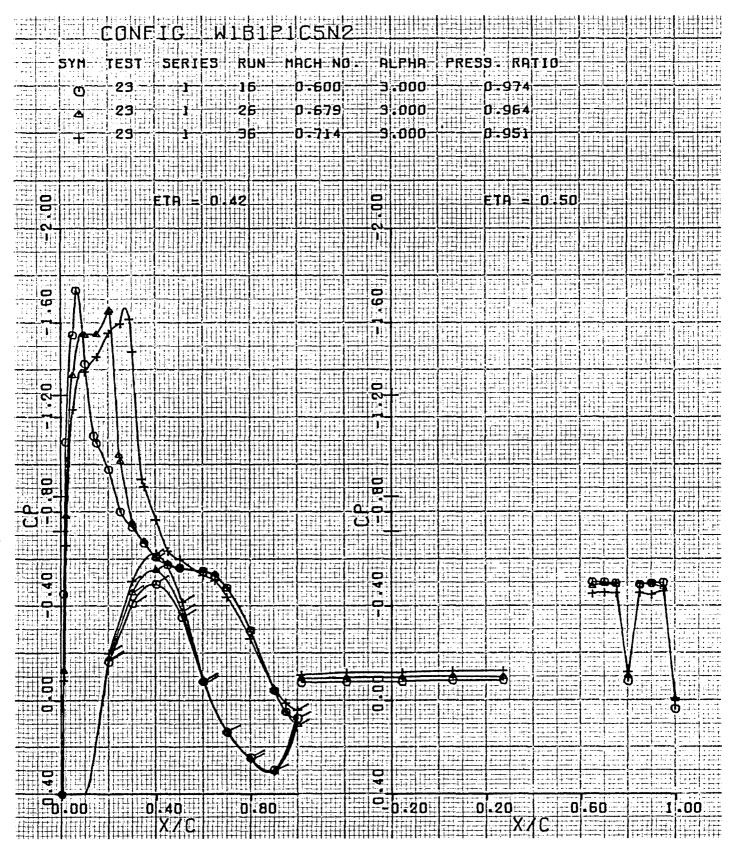


Figure 52. Wing pressure distribution, effect of Mach number, nozzle N_2 , η = 0.42, 0.50

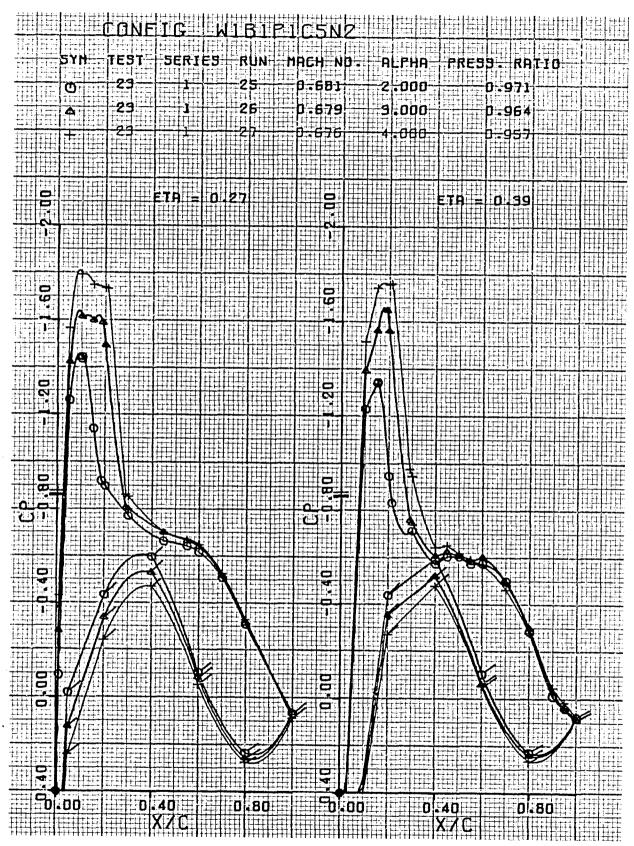


Figure 53. Wing pressure distribution, effect of α , nozzle N_2 , η = 0.27, 0.39

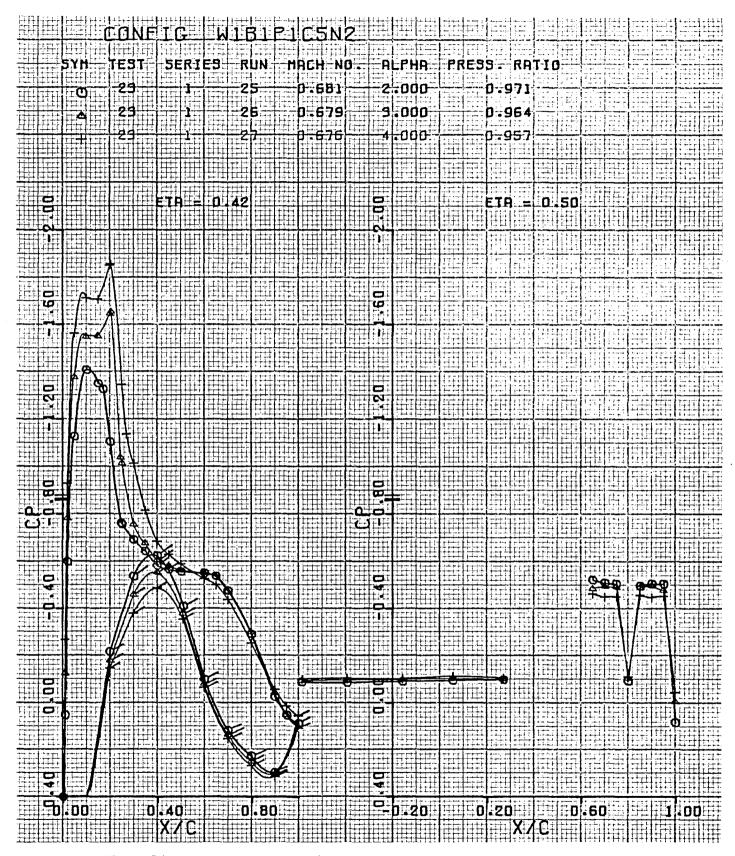


Figure 54. Wing pressure distribution, effect of α , nozzle N_2 , η = 0.42, 0.50

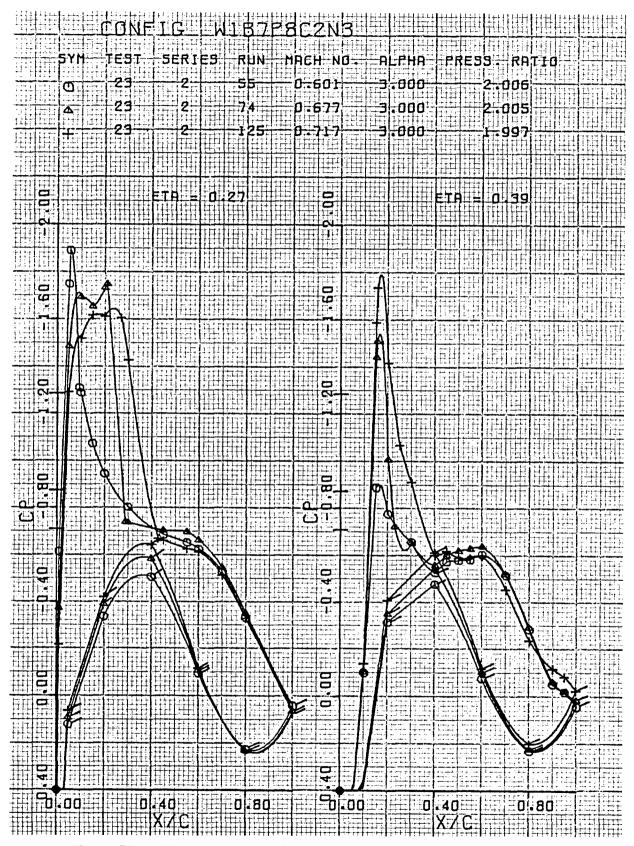


Figure 55. Wing pressure distribution, effect of Mach number, nozzle N $_3$, η = 0.27, 0.39

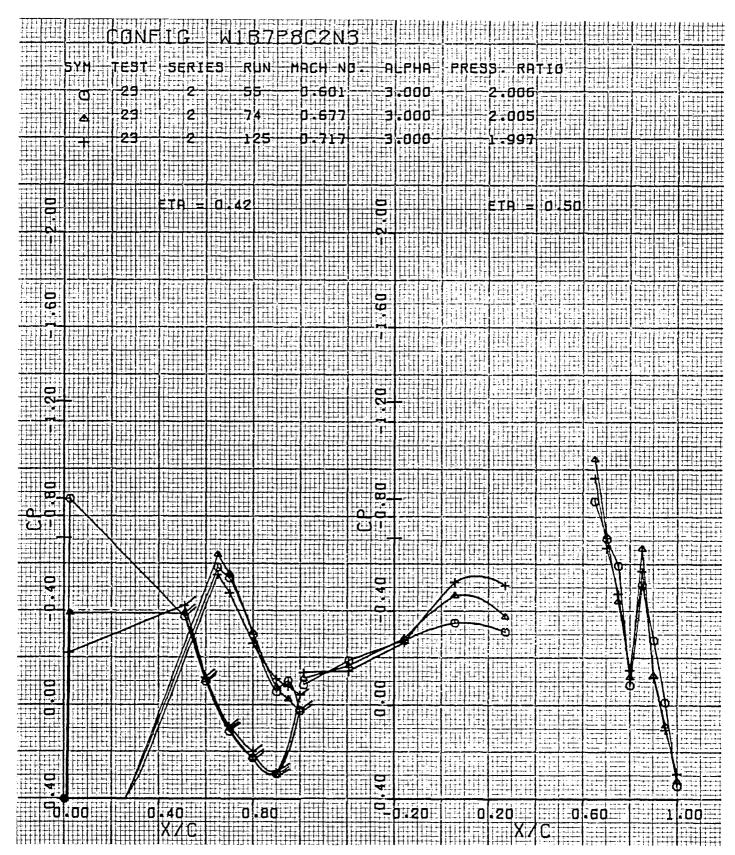


Figure 56. Wing pressure distribution, effect of Mach number, nozzle N_3 , η = 0.42, 0.50

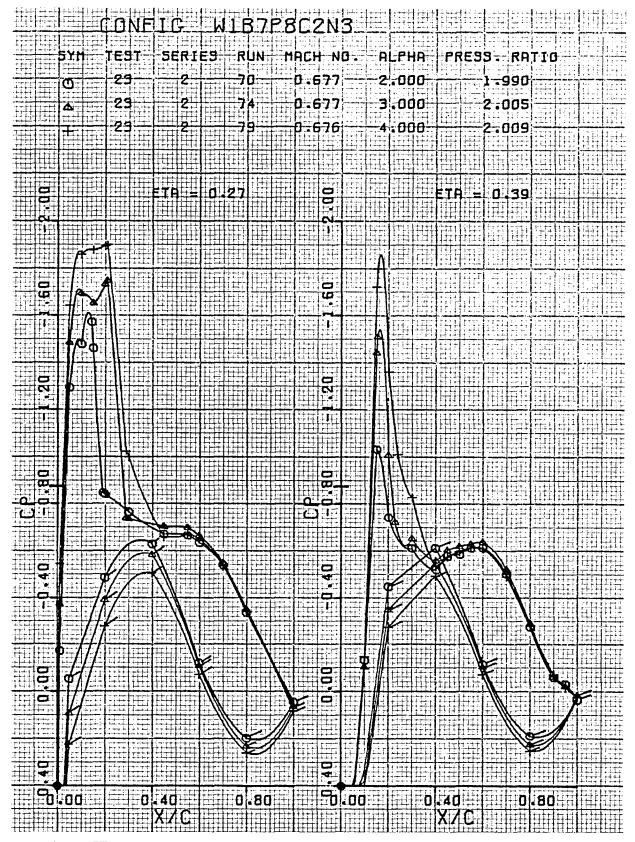


Figure 57. Wing pressure distribution, effect of α , nozzle N_3 , η = 0.27, 0.39

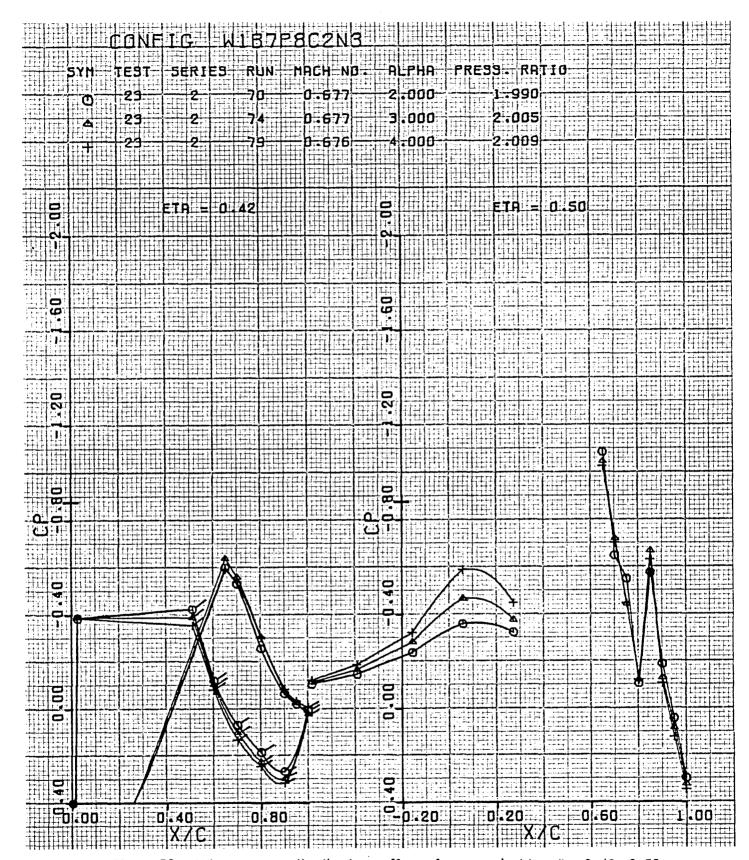


Figure 58. Wing pressure distribution, effect of α , nozzle N_3 , η = 0.42, 0.50

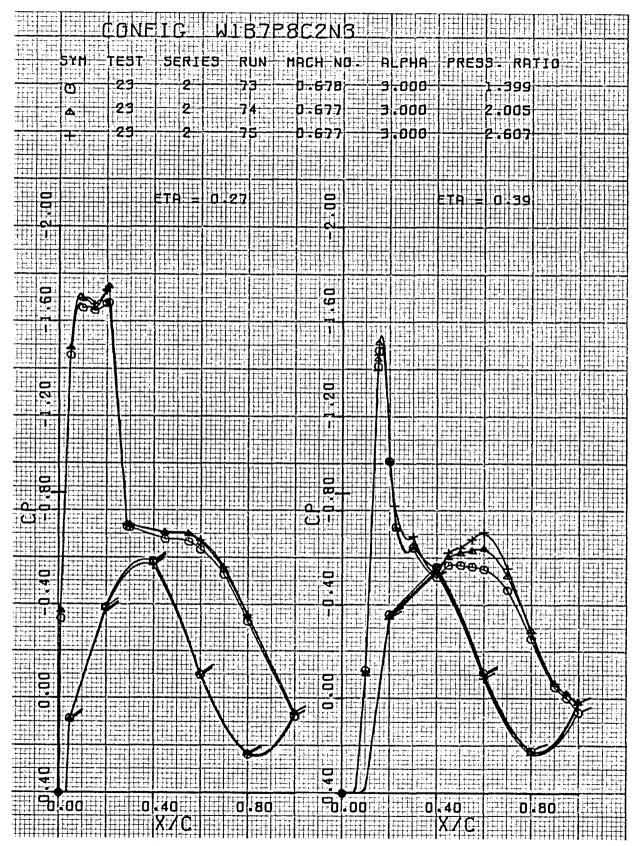


Figure 59. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N_3 , $\eta = 0.27, 0.39$

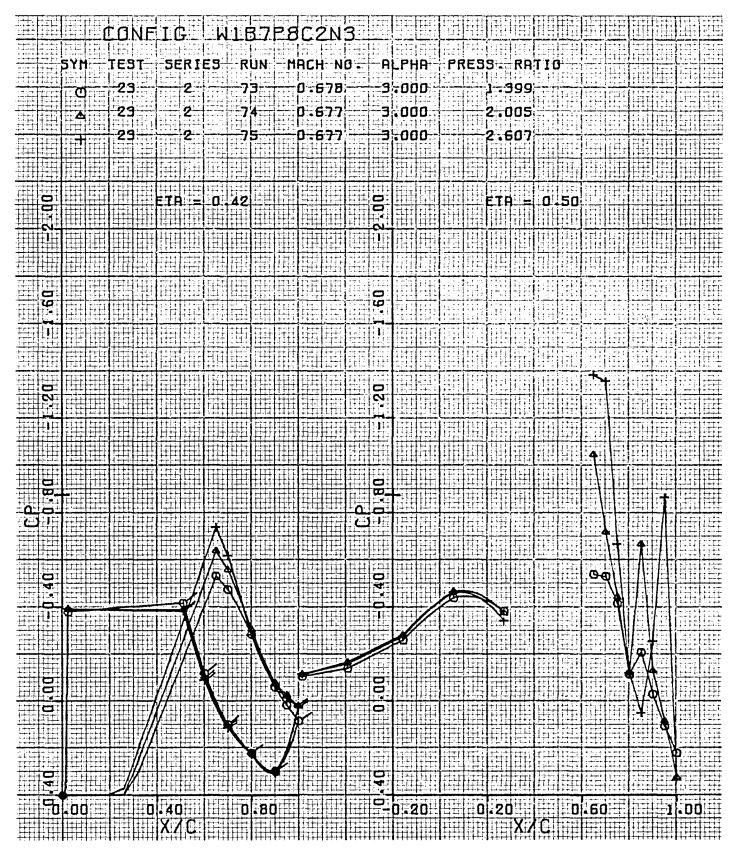


Figure 60. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N_3 , η = 0.42, 0.50

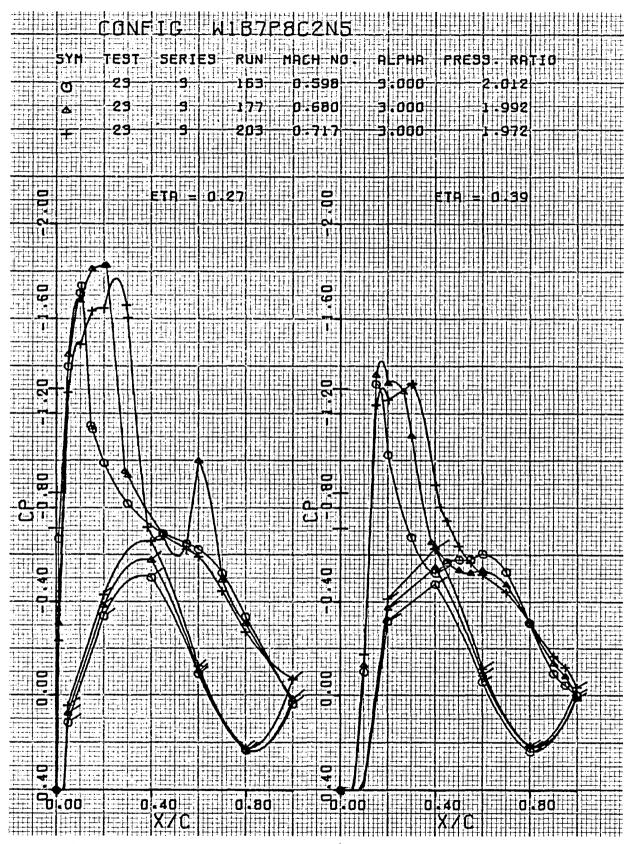


Figure 61. Wing pressure distribution, effect of Mach number, nozzle N_5 , η = 0.27, 0.39

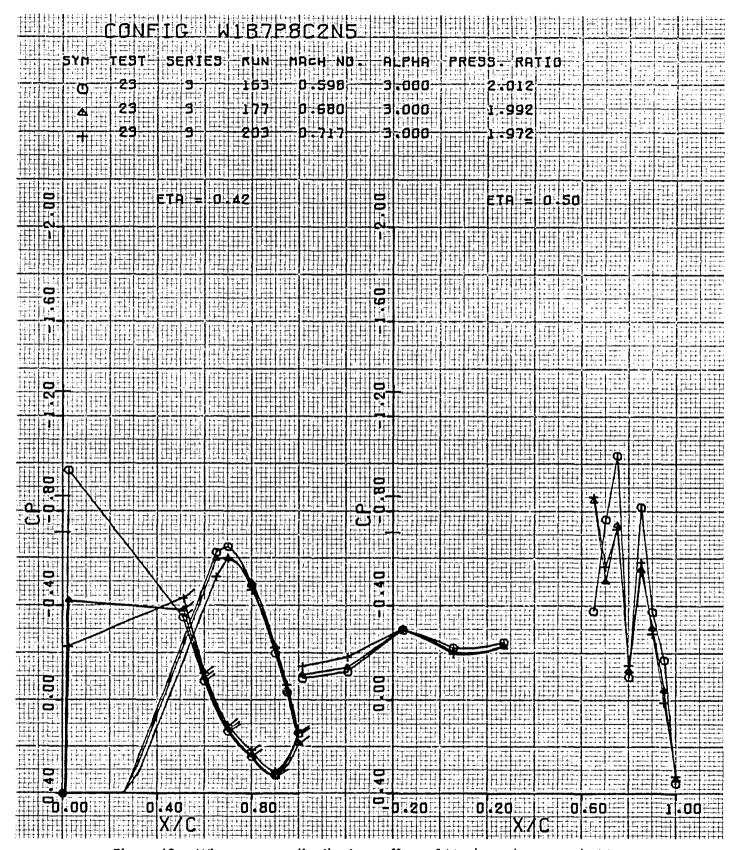


Figure 62. Wing pressure distribution, effect of Mach number, nozzle N_5 , η = 0.42, 0.50

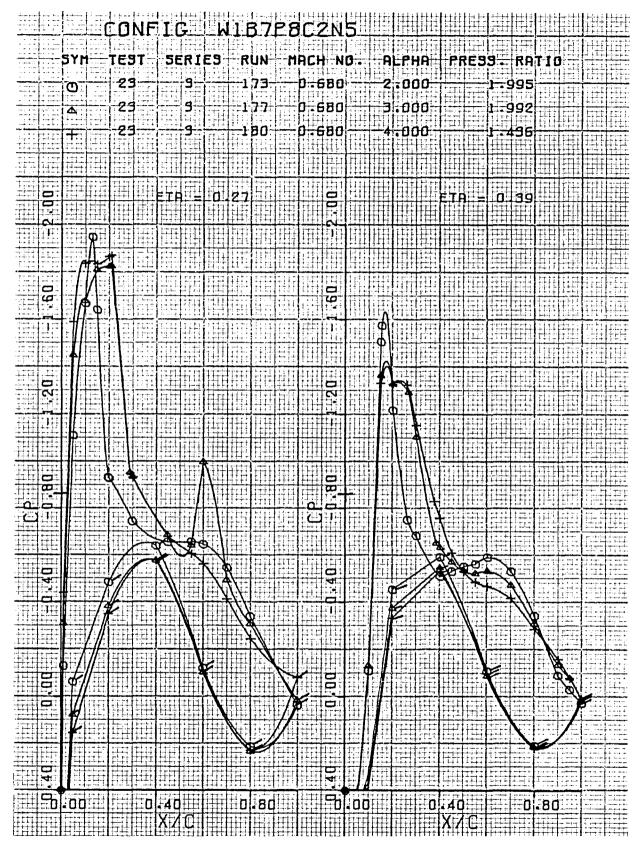


Figure 63. Wing pressure distribution, effect of α , nozzle N₅, η = 0.27, 0.39

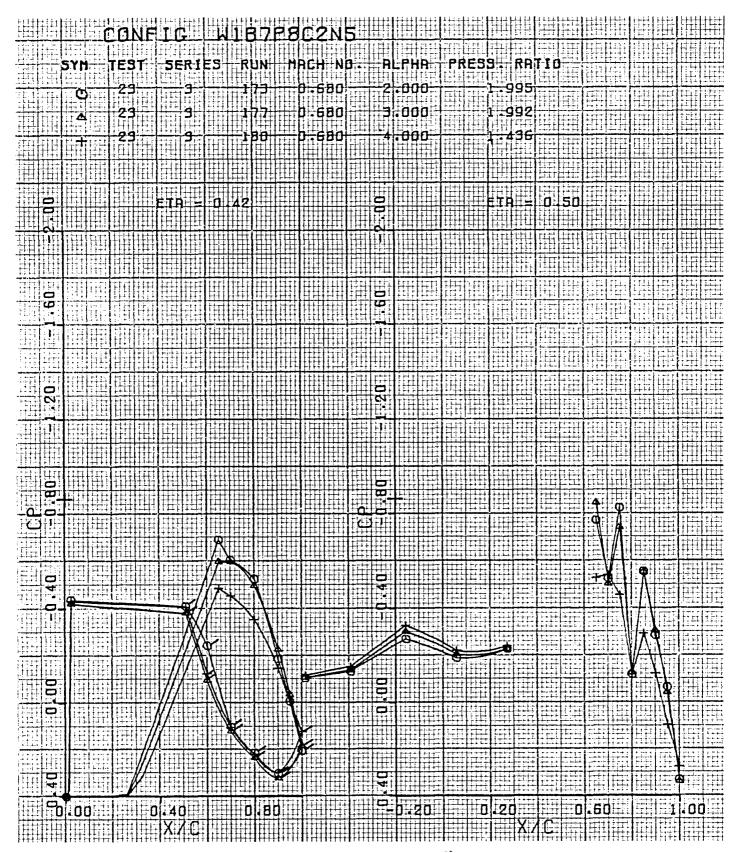


Figure 64. Wing pressure distribution, effect of α , nozzle N₅, η = 0.42, 0.50

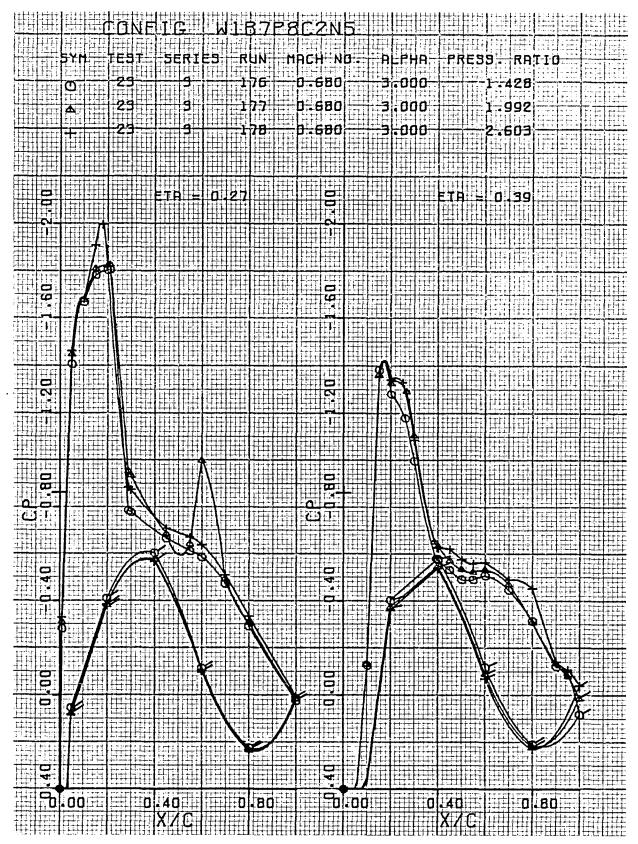


Figure 65. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N_5 , $\eta = 0.27, 0.39$

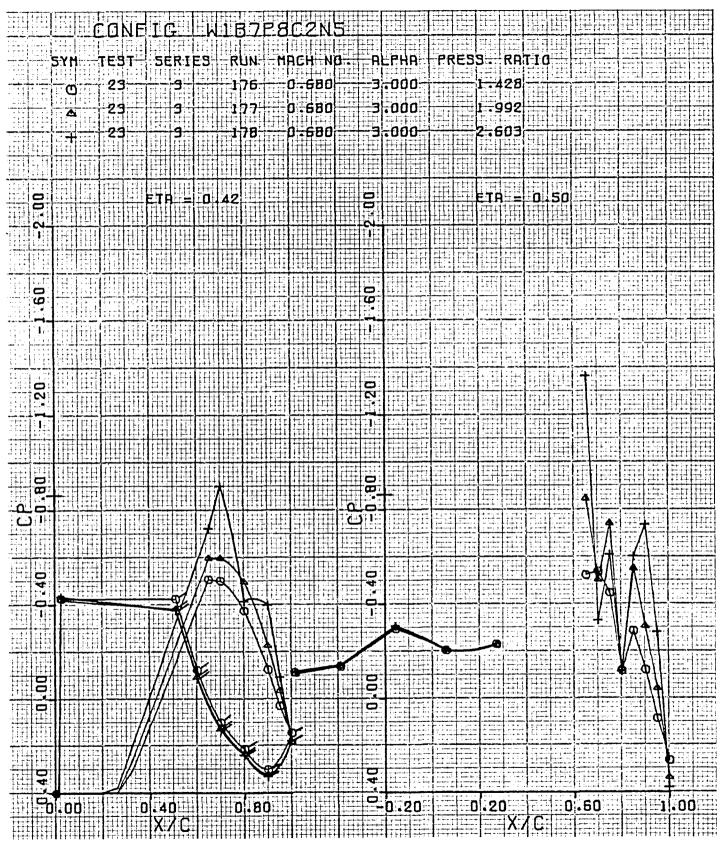


Figure 66. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N_5 , $\eta = 0.42, 0.50$

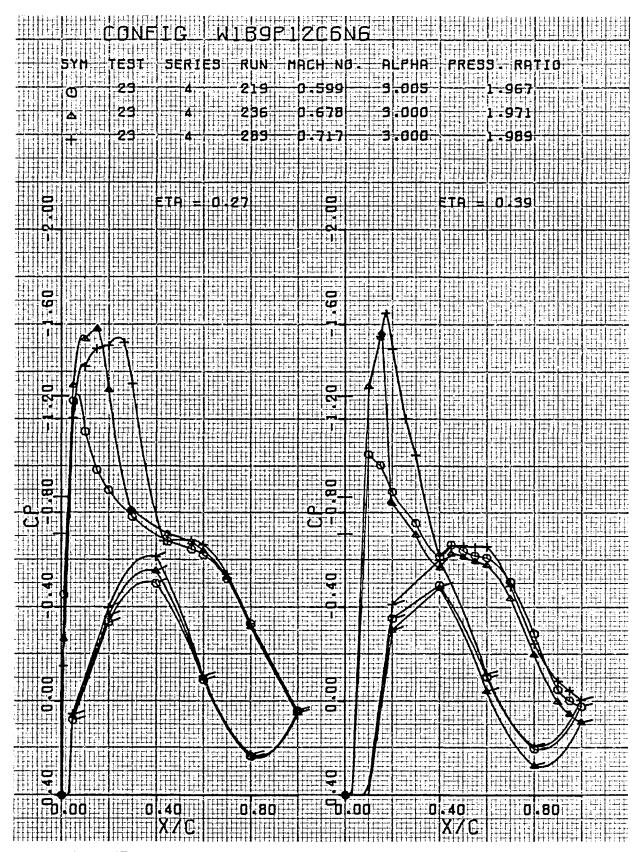


Figure 67. Wing pressure distribution, effect of Mach number, nozzle N_6 , $\eta = 0.27, 0.39$

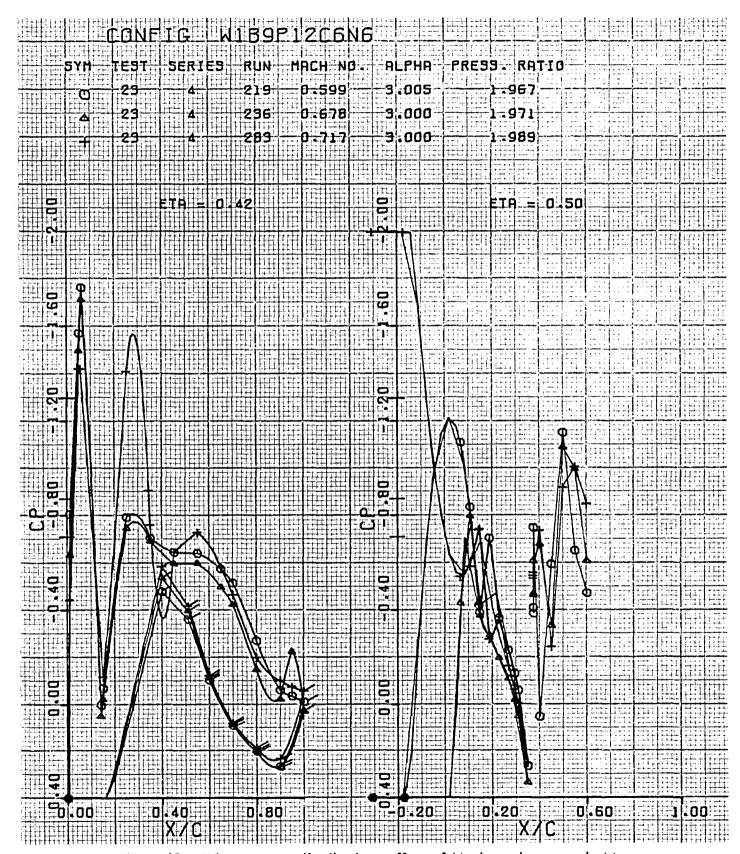


Figure 68. Wing pressure distribution, effect of Mach number, nozzle N_6 , $\eta = 0.42, 0.50$

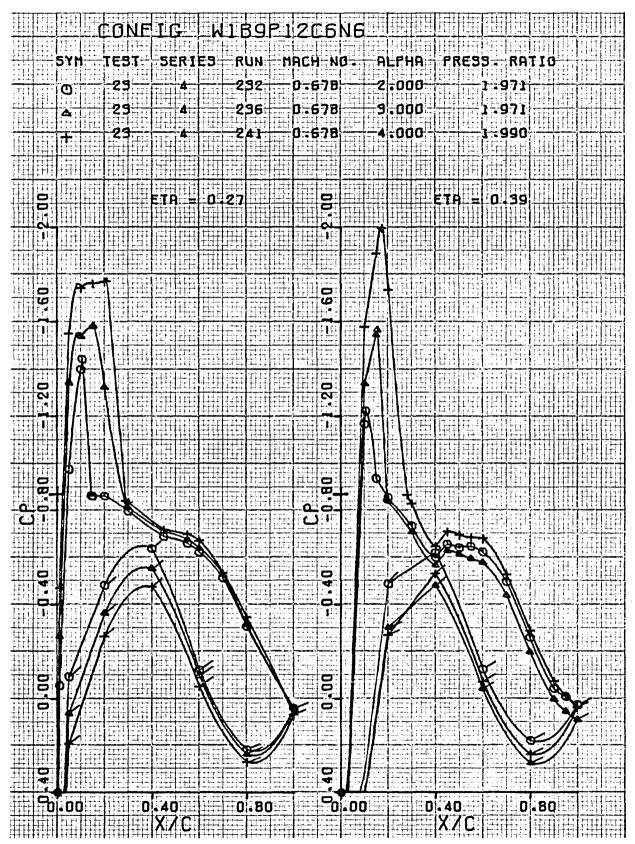


Figure 69. Wing pressure distribution, effect of α , nozzle N_6 , η = 0.27, 0.39

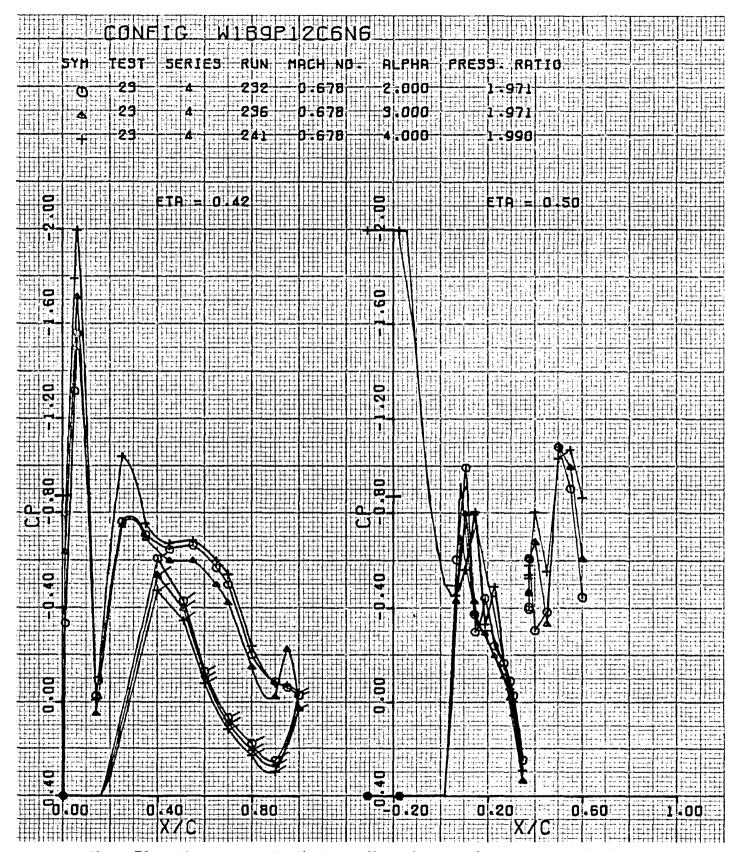


Figure 70. Wing pressure distribution, effect of α , nozzle N₆, η = 0.42, 0.50

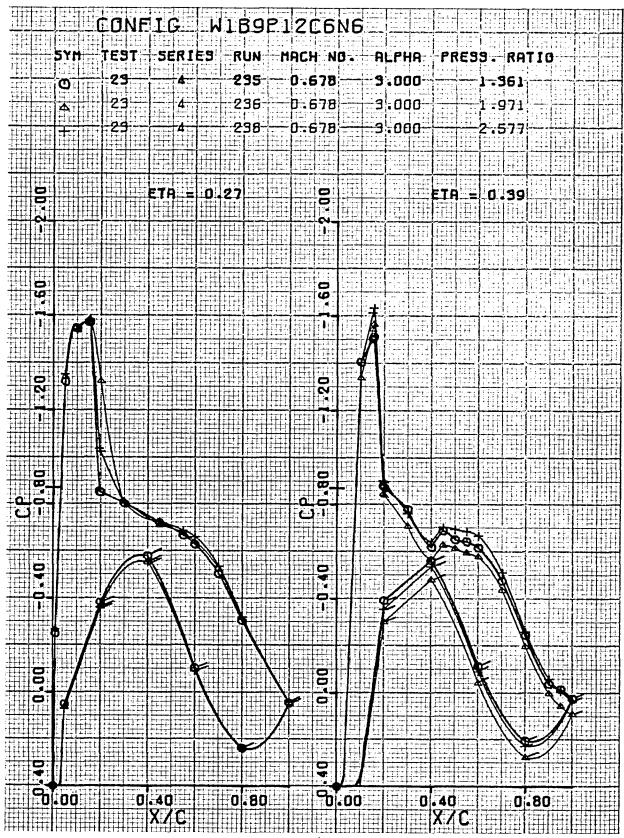


Figure 71. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N₆ , η = 0.27, 0.39

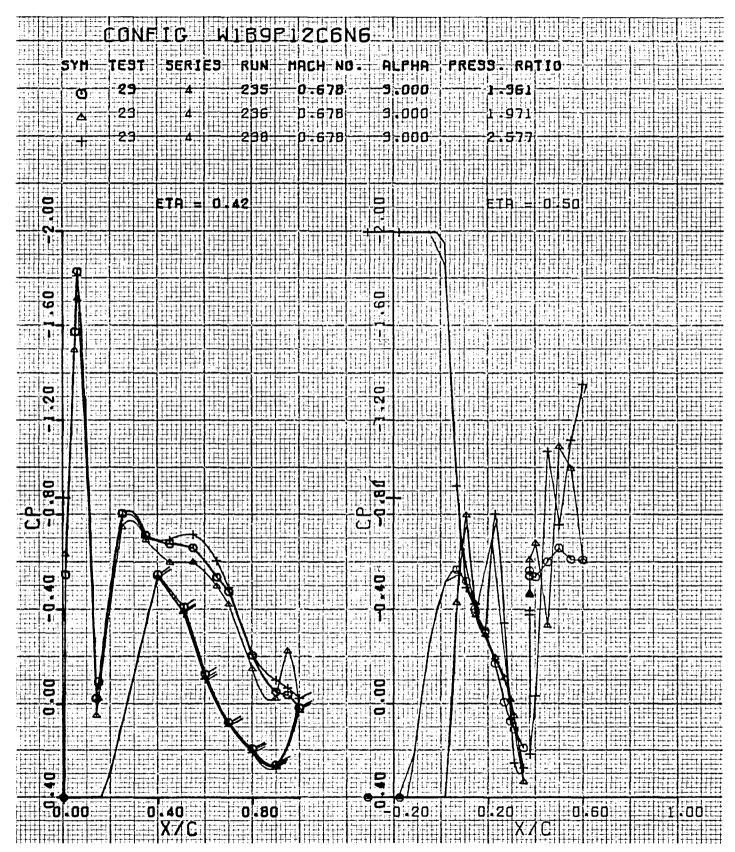


Figure 72. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N_6 , η = 0.42, 0.50

5.3 Model Pressure Distributions, Upstream Pipe Installation

Pressure distributions for models tested on the upstream pipe installation are presented in Figures 73 through 104. Presentation format is identical to that used for the long nozzle series. Reasons for use of the upstream pipe arrangement were two-fold. First, it was desired to test over-the-wing nacelles mounted on thin pylons across the complete range of nozzle pressure ratios. Nozzles on these configurations could not be supplied through the wing in the usual manner. Then, second, it was desired to vary the chordwise nozzle discharge position. The upstream pipe in conjunction with various combinations of nacelle spacers and wing mounting pads provided the flexibility required to accomplish this objective.

The first group of data in this section is for a circular nozzle, N_2 , mounted on a pylon. This is followed by data for the intermediate D-duct nozzle, N_3 , at chordwise positions (x/c noted at top of figures) of 0.35, 0.50, and 0.20. In the last group for this series, data is presented for the large D-duct nozzle, N_1 , at the same chordwise positions as for N_3 . All data in this series are presented at a Reynold's number of 3.5 million based on wing chord.

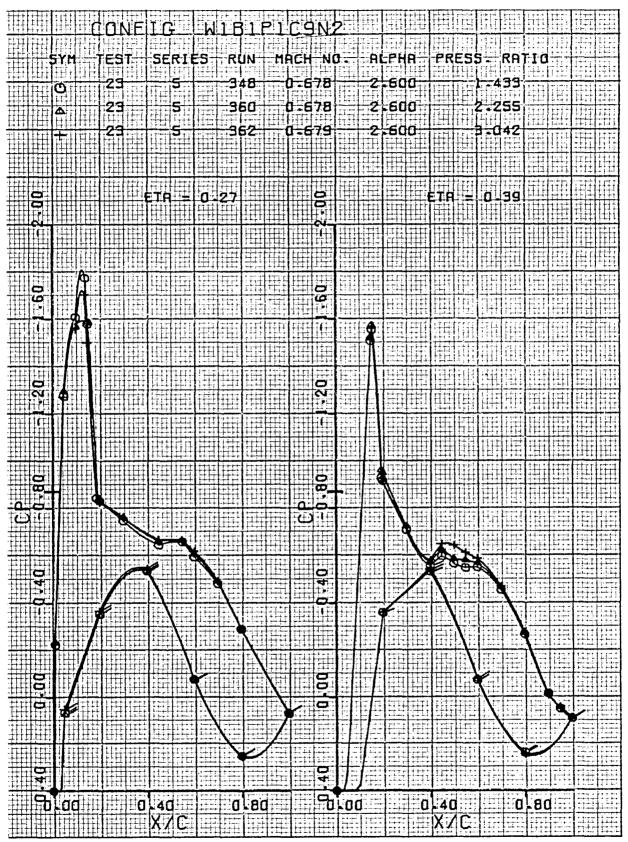


Figure 73. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N_2 , $\eta = 0.27, 0.39$

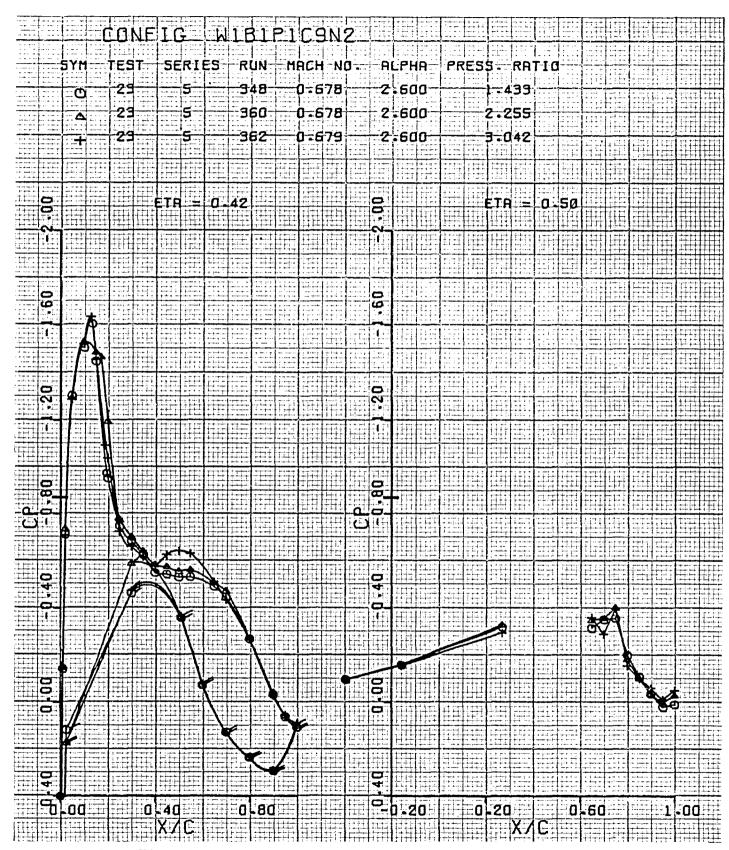


Figure 74. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N $_2$, η = 0.42, 0.50

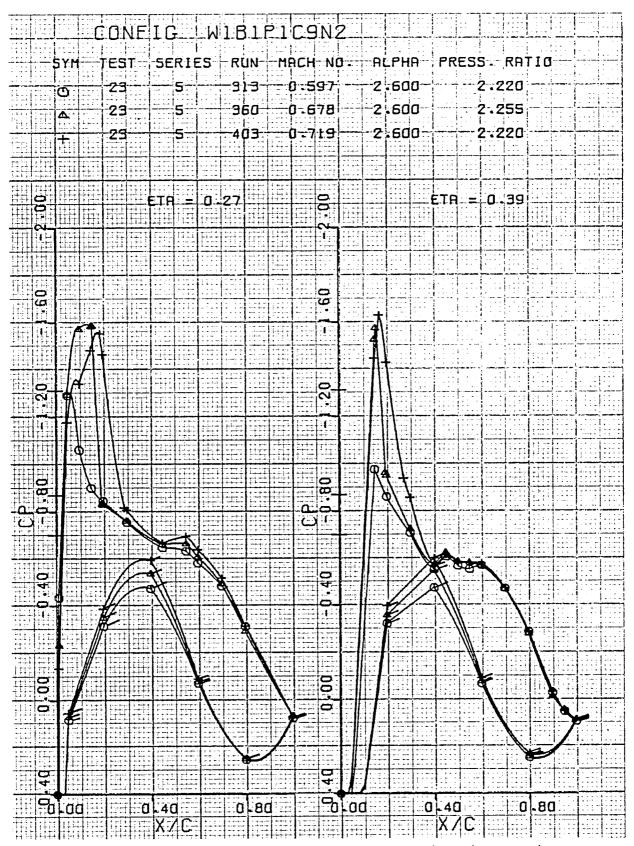


Figure 75. Wing pressure distribution, effect of Mach number, nozzle N_2 , η = 0.27, 0.39

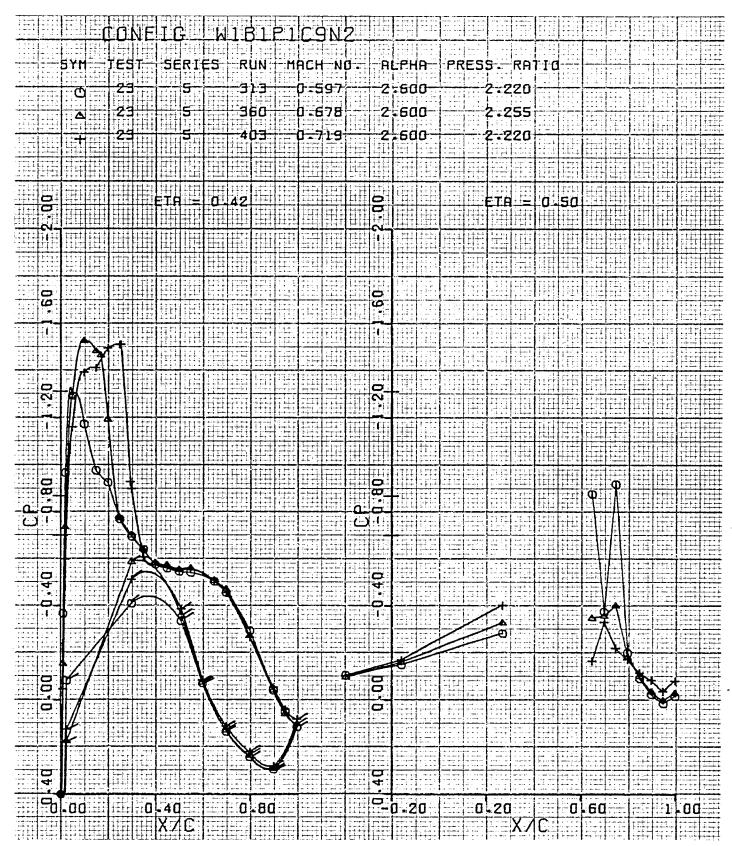


Figure 76. Wing pressure distribution, effect of Mach number, nozzle N $_2$, η = 0.42, 0.50

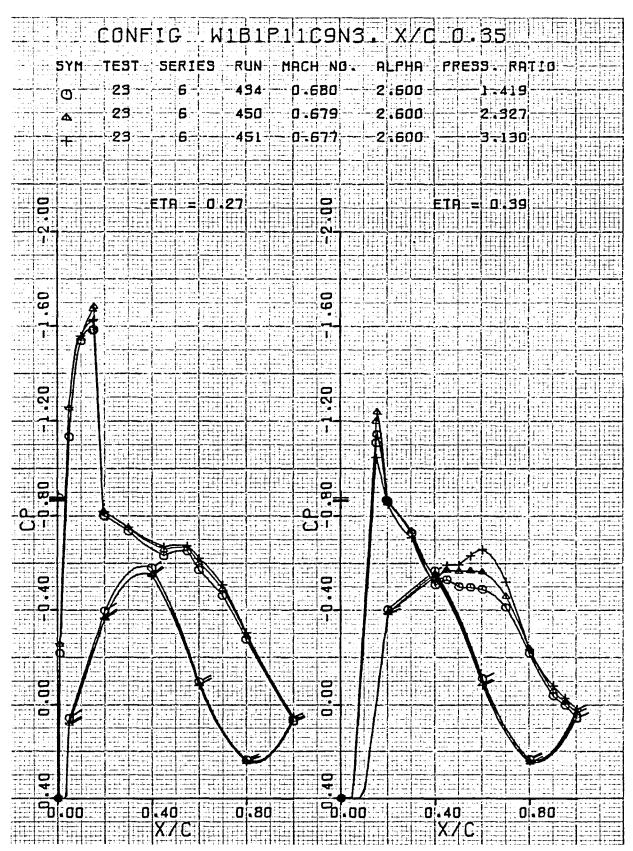


Figure 77. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N_3 , x/c = 0.35, $\eta = 0.27$, 0.39

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Figure 78. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N $_3$, $_{\rm x/c}$ = 0.35, $_{\rm 1}$ = 0.42, 0.50

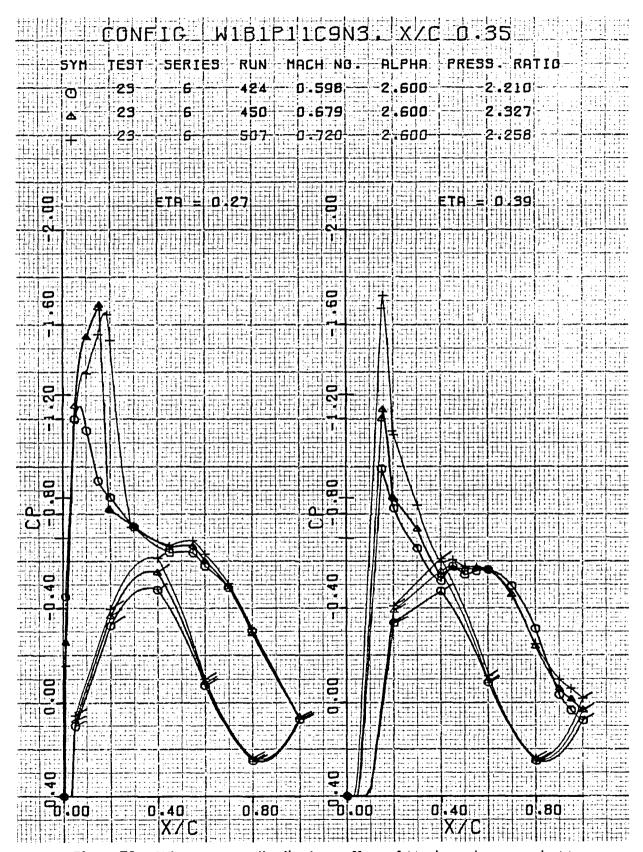


Figure 79. Wing pressure distribution, effect of Mach number, nozzle N_3 , \times/c = 0.35, η = 0.27, 0.39

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Figure 80. Wing pressure distribution, effect of Mach number, nozzle N $_3$, x/c = 0.35, η = 0.42, 0.50

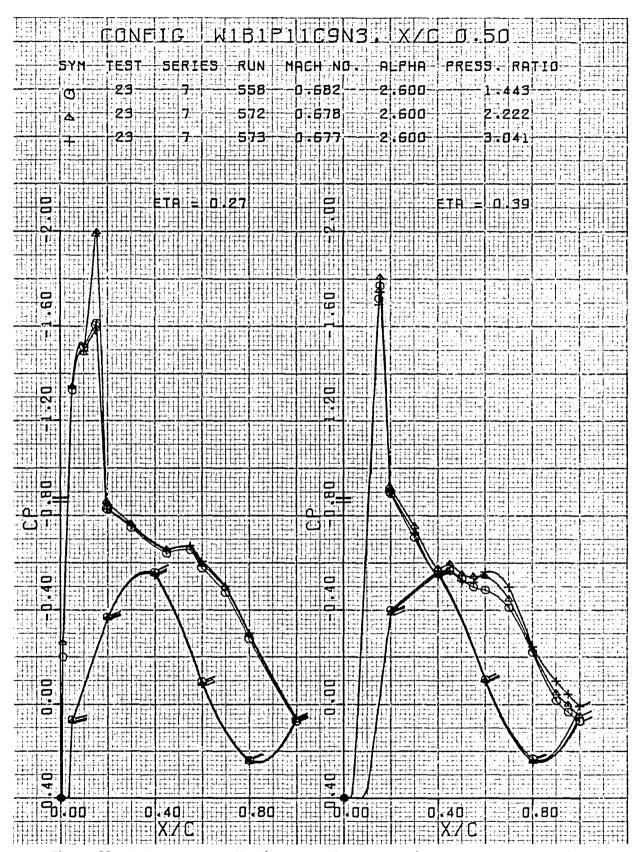


Figure 81. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N_3 , x/c = 0.50, $\eta = 0.27$, 0.39

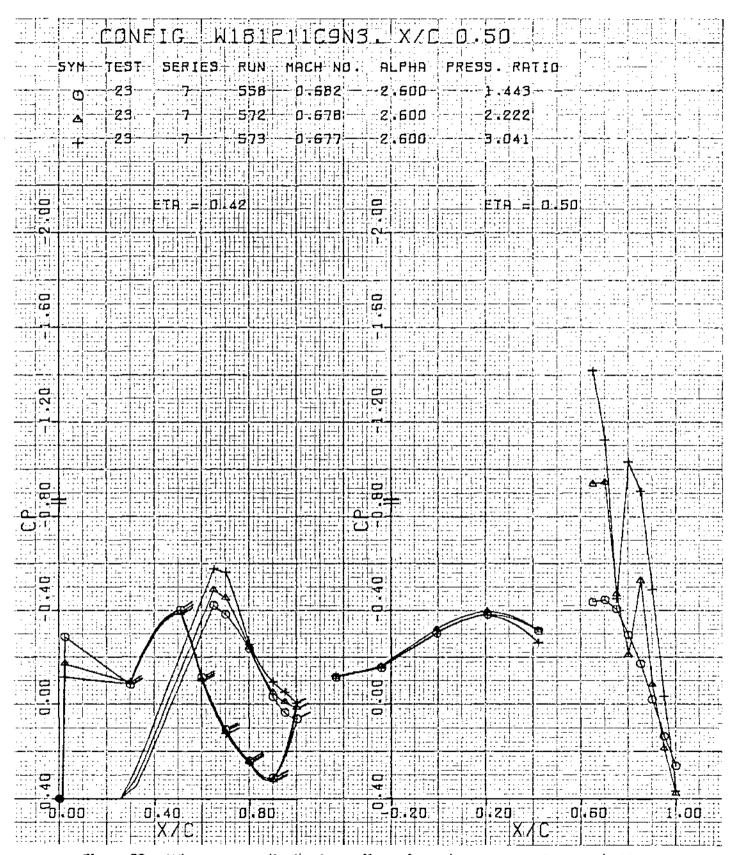


Figure 82. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N $_3$, x/c = 0.50, η = 0.42, 0.50

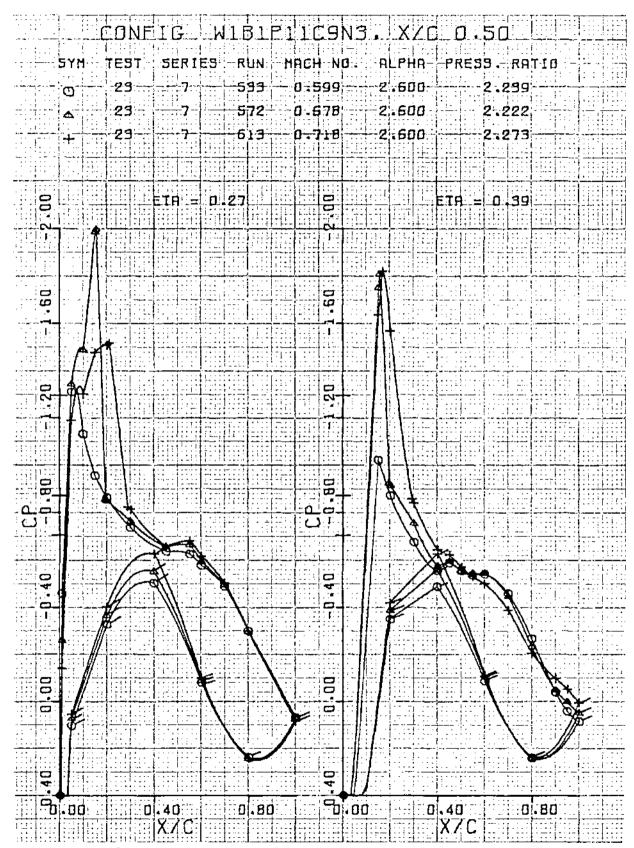


Figure 83. Wing pressure distribution, effect of Mach number, nozzle N_3 , x/c = 0.50, $T_i = 0.27$, 0.39

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Figure 84. Wing pressure distribution, effect of Mach number, nozzle N_3 , x/c = 0.50, $\eta = 0.42$, 0.50

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Figure 85. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N $_3$, x/c = 0.20, η = 0.27, 0.39

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Figure 86. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N $_3$, $_{\rm x/c}$ = 0.20, $_{\rm 1}$ = 0.42, 0.50

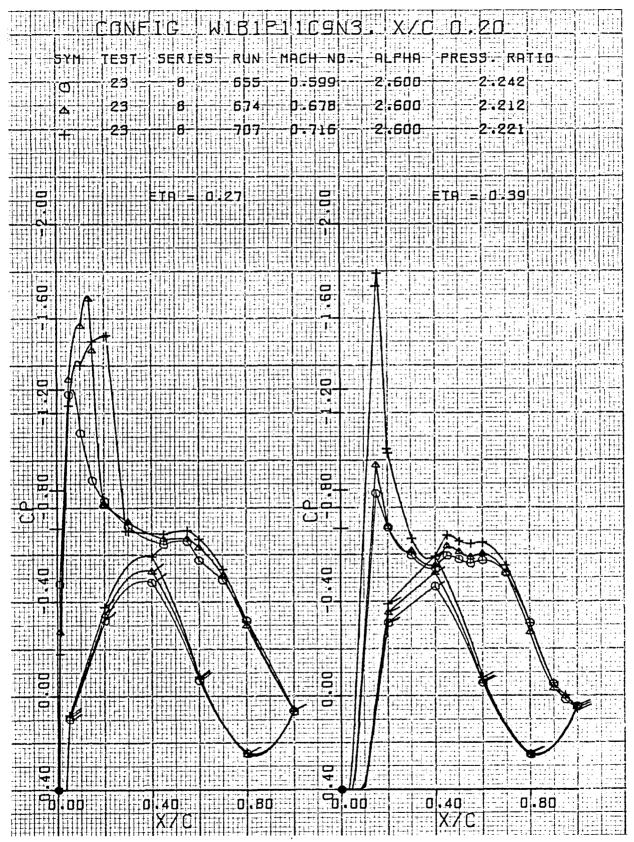


Figure 87. Wing pressure distribution, effect of Mach number, nozzle N $_3$, $_{\times/c}$ = 0.20, η = 0.27, 0.39

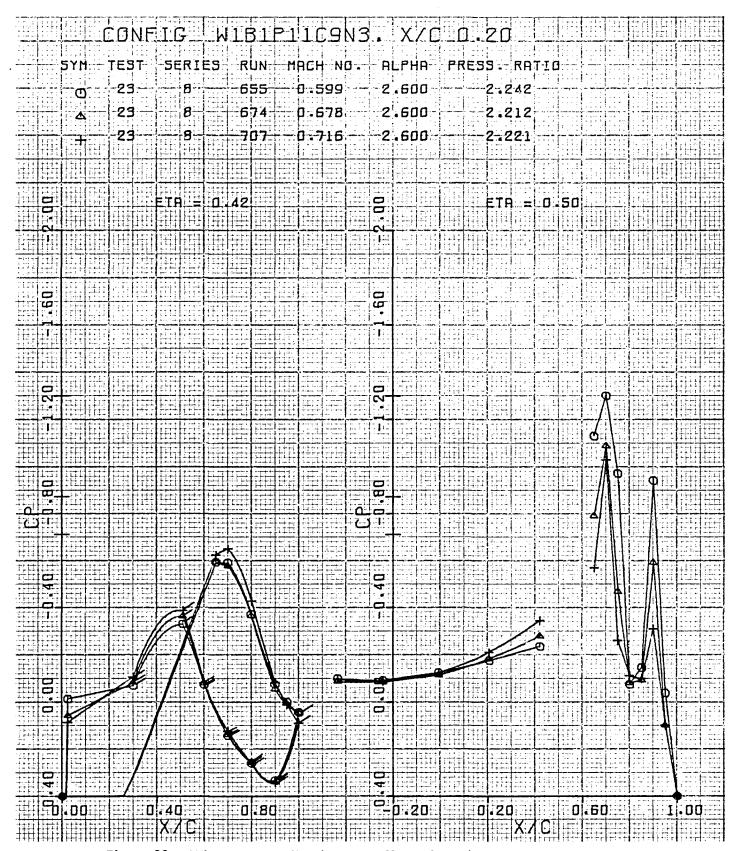


Figure 88. Wing pressure distribution, effect of Mach number, nozzle N_3 , \times/c = 0.20, η = 0.42, 0.50

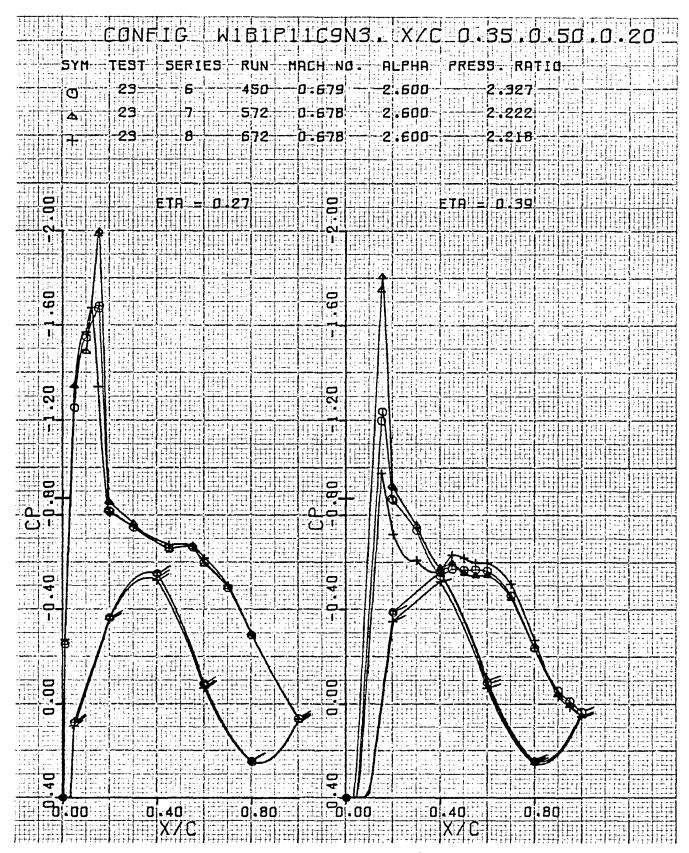


Figure 89. Wing pressure distribution, effect of x/c, nozzle N_3 , $\eta = 0.27$, 0.39

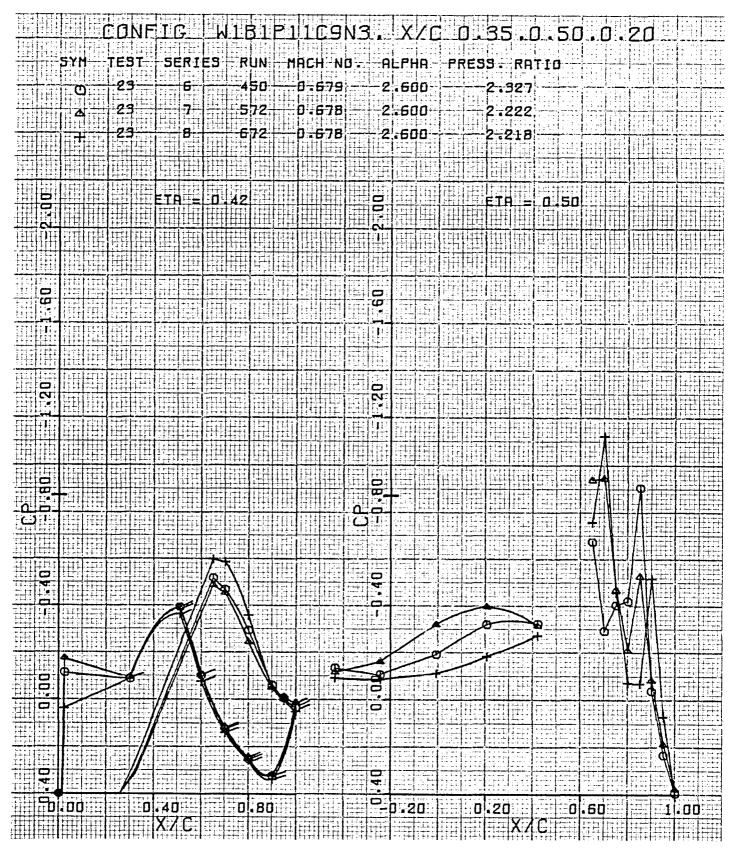


Figure 90. Wing pressure distribution, effect of x/c, nozzle N_3 , η = 0.42, 0.50

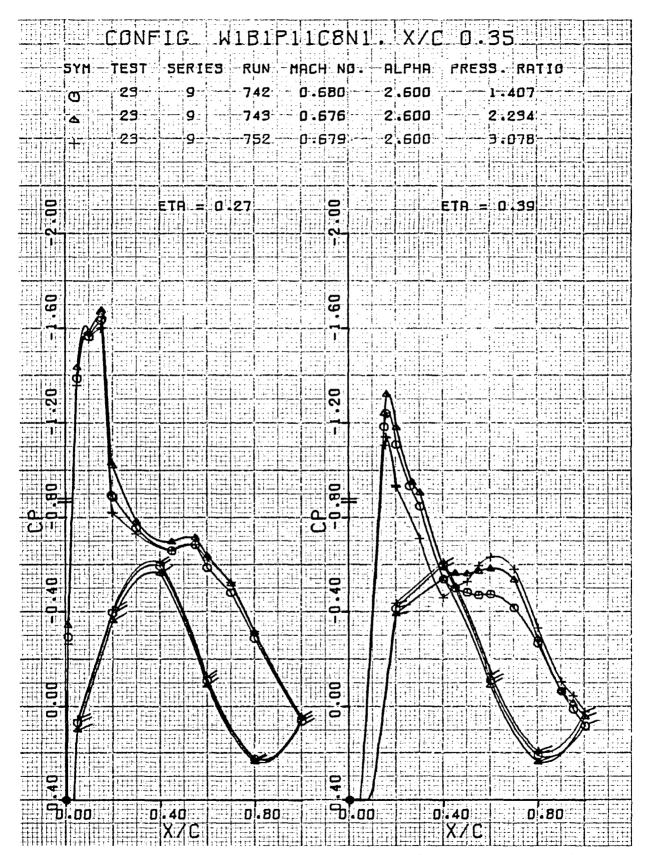


Figure 91. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N_1 , x/c = 0.35, $\eta = 0.27$, 0.39

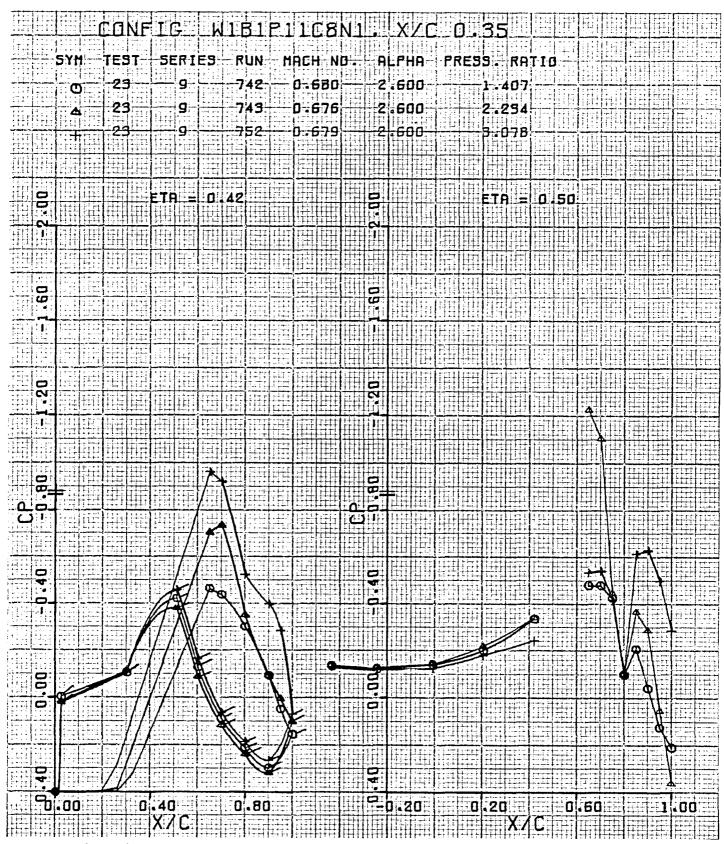


Figure 92. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N_1 , $\times/c = 0.35$, $\eta = 0.42$, 0.50

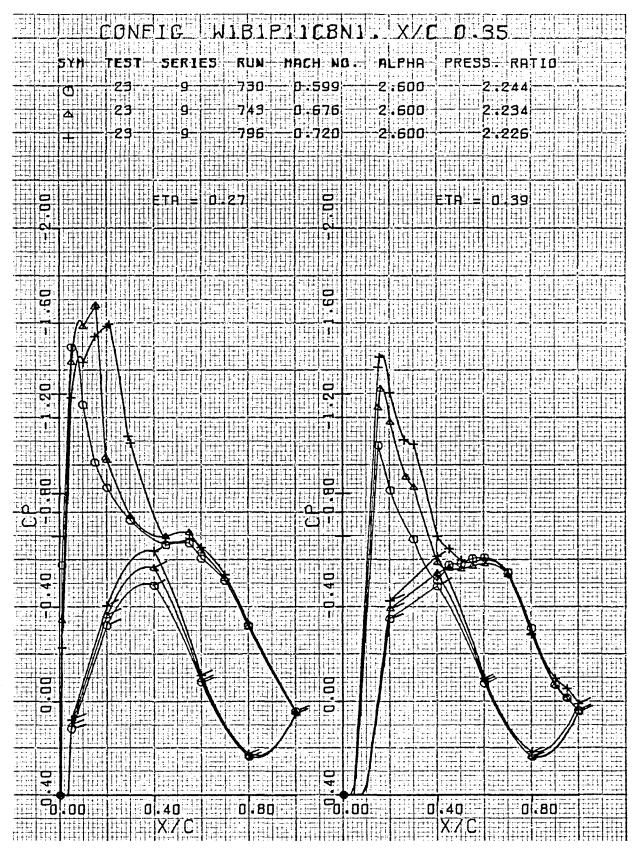


Figure 93. Wing pressure distribution, effect of Mach number, nozzle N_1 , x/c = 0.35, $\eta = 0.27$, 0.39

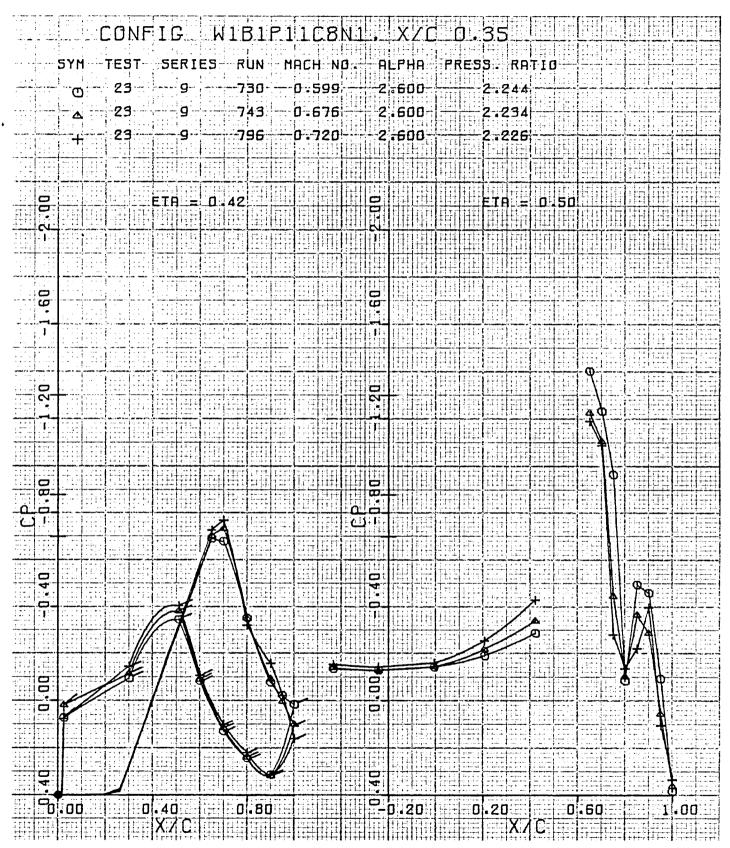


Figure 94. Wing pressure distribution, effect of Mach number, nozzle N_1 , $\times/c = 0.35$, $\eta = 0.42$, 0.50

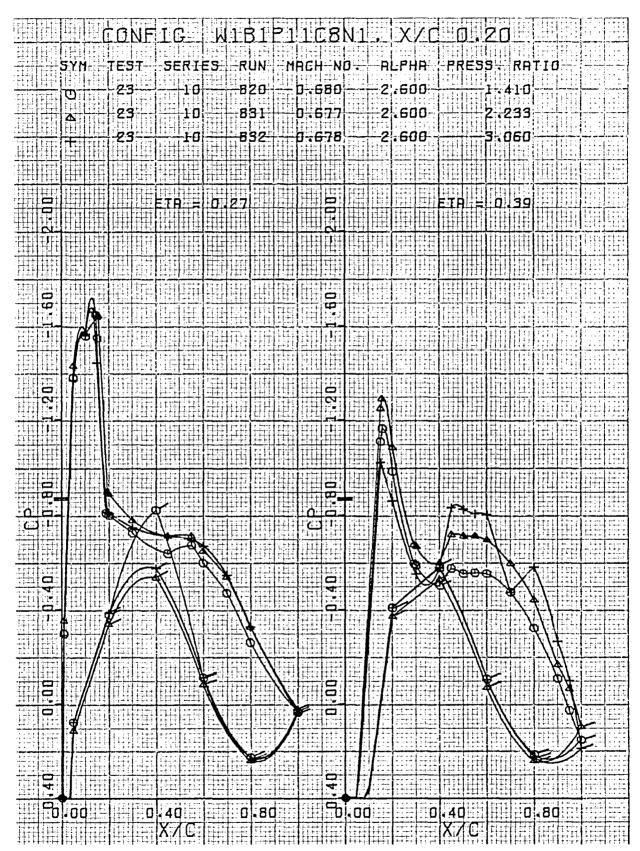


Figure 95. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N_1 , x/c = 0.20, $\eta = 0.27$, 0.39

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Figure 96. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N $_1$, $_{\times/c}$ = 0.20, $_{1}$ = 0.42, 0.50

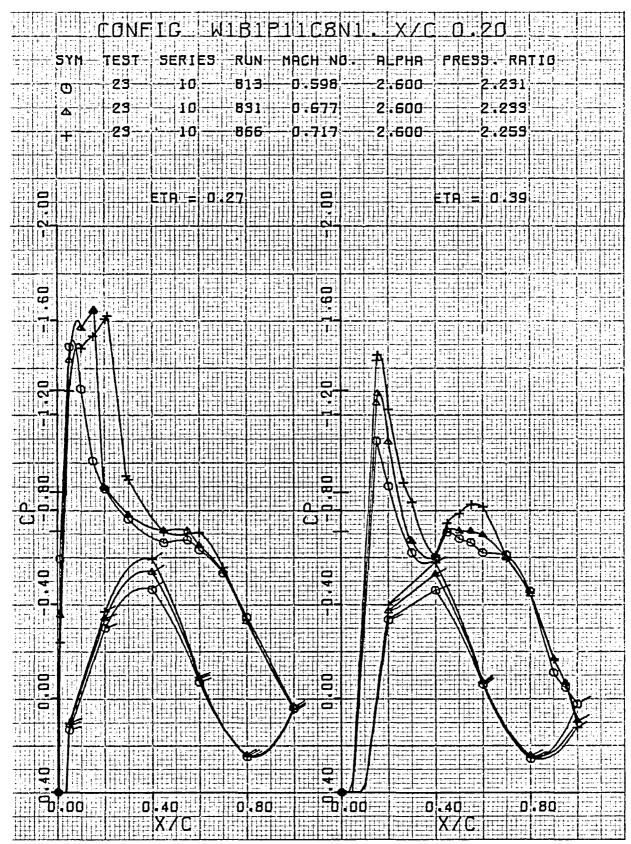


Figure 97. Wing pressure distribution, effect of Mach number, nozzle N_1 , $\times/c = 0.20$, $\eta = 0.27$, 0.39

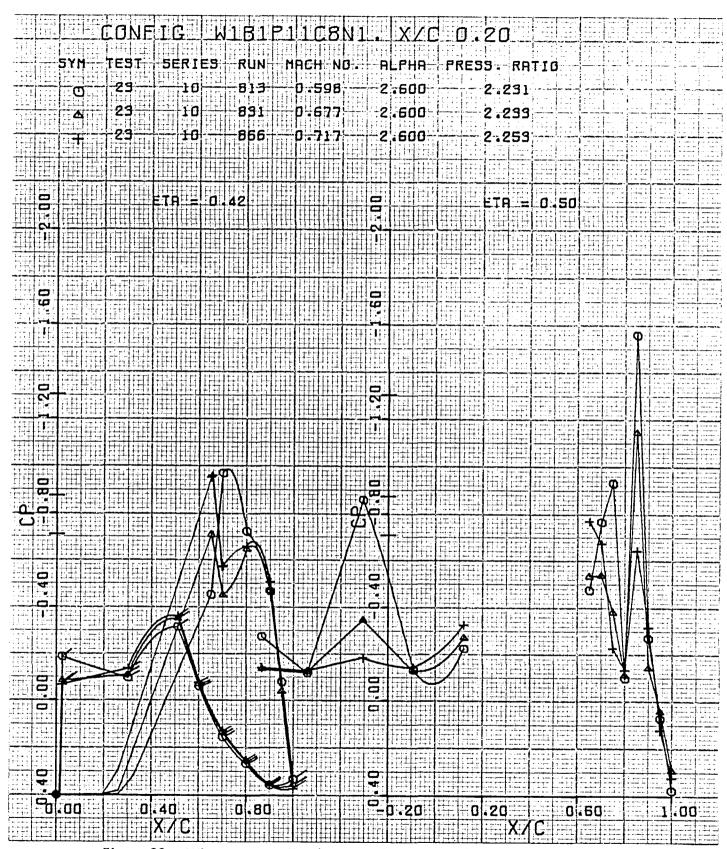
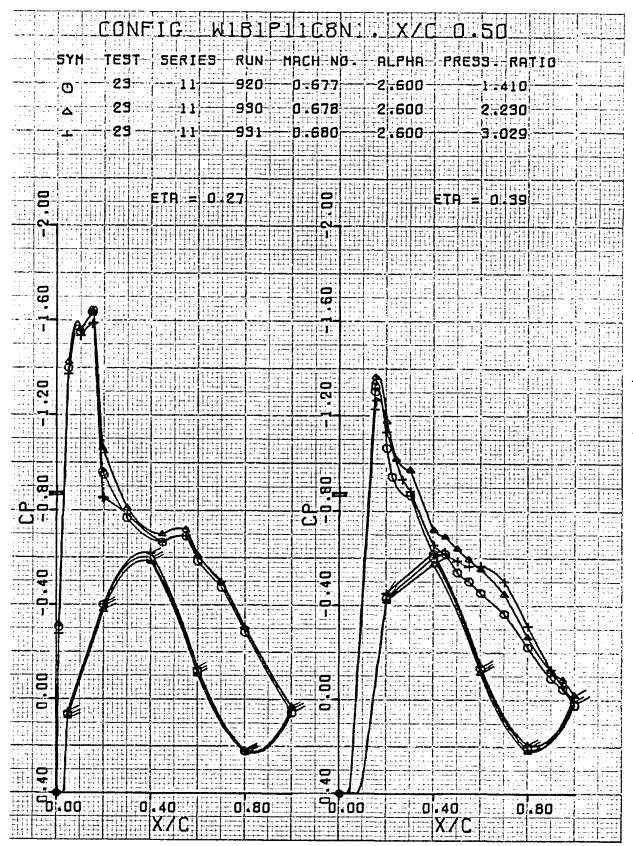


Figure 98. Wing pressure distribution, effect of Mach number, nozzle N_1 , x/c = 0.20, $\eta = 0.42$, 0.50



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Figure 100. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N $_{1}$, x/c = 0.50, η = 0.42, 0.50

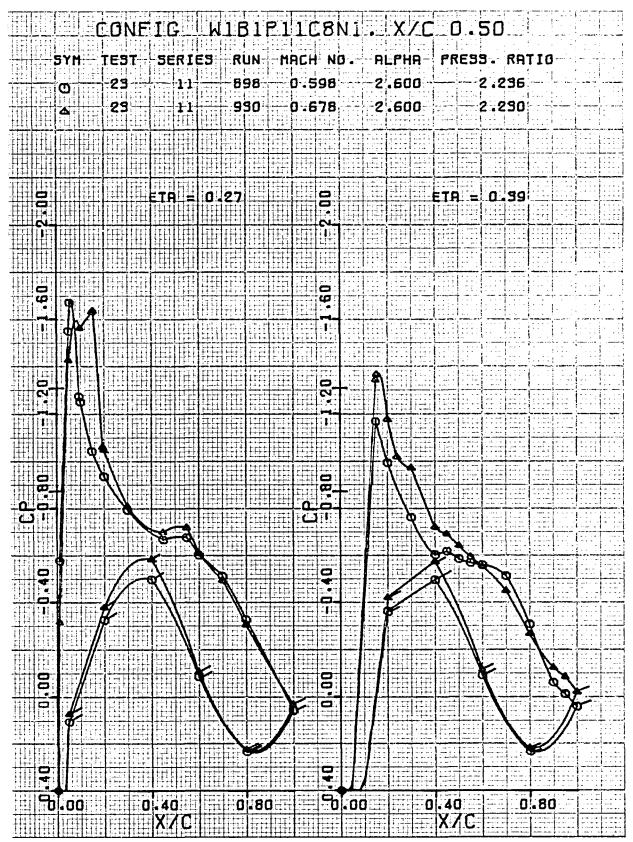


Figure 101. Wing pressure distribution, effect of Mach number, nozzle N_1 , x/c = 0.50, $\eta = 0.27$, 0.39

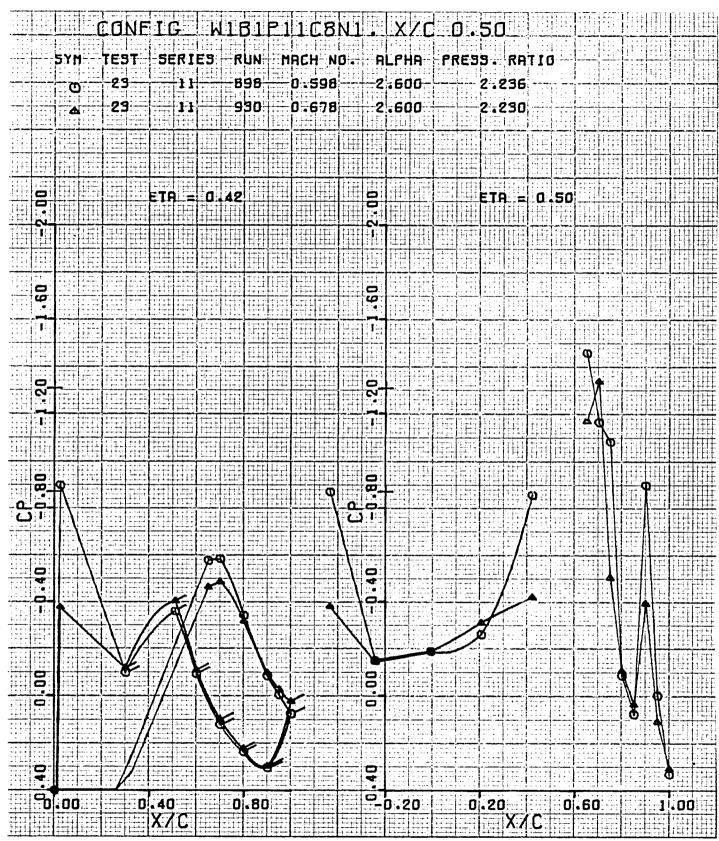


Figure 102. Wing pressure distribution, effect of Mach number, nozzle N_1 , x/c = 0.50, $\eta = 0.42$, 0.50

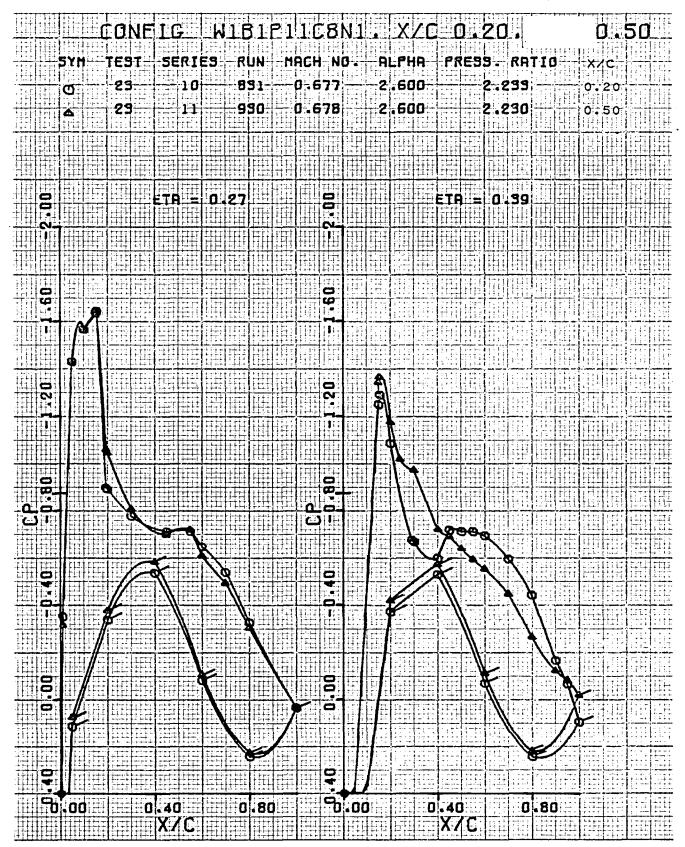


Figure 103. Wing pressure distribution, effect of x/c, nozzle N_1 , η = 0.27, 0.39

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Figure 104. Wing pressure distribution, effect of x/c, nozzle N_1 , $\eta = 0.42$, 0.50

5.4 Wake Pressure Patterns

Isobars in terms of local total pressure ratios measured one chord length downstream of the wing trailing edge are presented in Figures 105 through 144. Figure 105 is an illustrative example of how an axial projection of the model (nozzle, wing, and pylon fairing) is positioned relative to the coordinate system for the isobars. This relative position is maintained throughout the rest of the isobar figures, although the model projection is not shown.

Model configurations for which wake patterns are presented are selected from the preceding two groups for which pressure distributions are shown. These include N_2 , pylon mounted, plus N_3 , N_5 , and N_6 . Nozzles N_2 and N_3 are presented for both upstream pipe and standard installations.

USB CRUISE PROGRAM CONFIG W₁ B₇ P₈ C₂ N₃

NOZZLE PRESSURE RATIO, $H_1/P_{\infty} = 2.2$

$$M_{\infty} = 0.70$$

$$\alpha = 2.6^{\circ}$$

NOTES:

- (1) CHORD LENGTH, c, IS 0.1778M (7.0 INCHES)
- (2) RAKE IS LOCATED ONE CHORD LENGTH BEHIND TRAILING EDGE
- (3) H_1/H_{∞} IS LOCAL TOTAL PRESSURE RATIO IN THE STREAM AS MEASURED BY THE RAKE

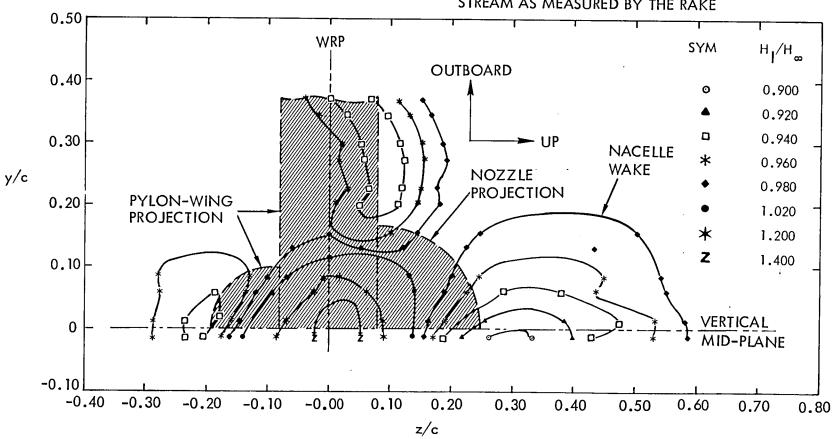


Figure 105. Wake isobar plot, illustration of how the model projection is oriented on grid

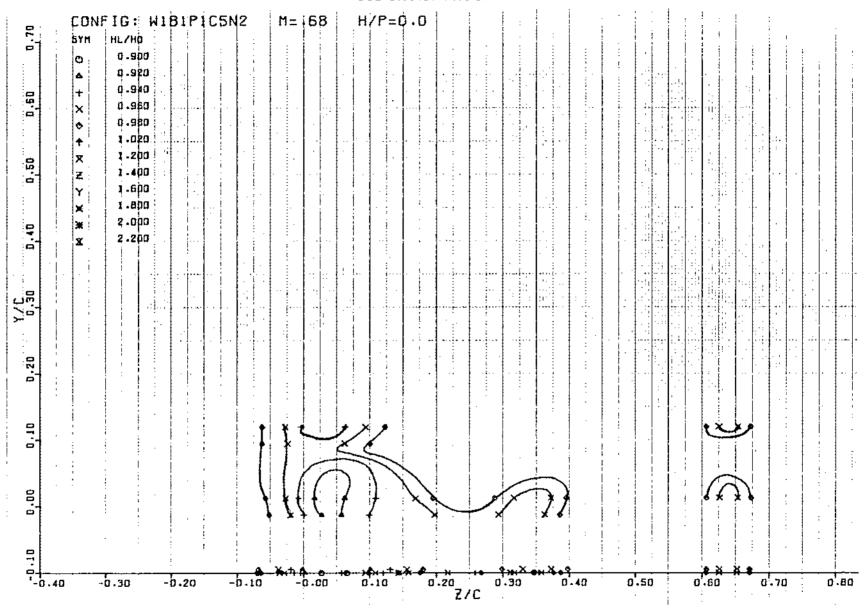


Figure 106. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$ test 23, series 1, run numbers 42-45, $\alpha = 3^\circ$

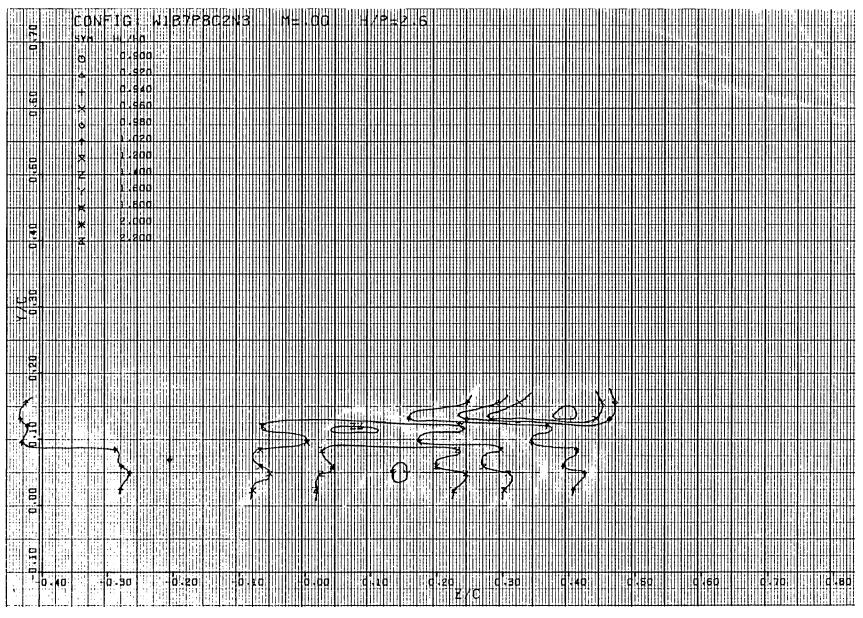


Figure 107. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$ test 23, series 2, run numbers 101 - 104, $\alpha = 0^0$

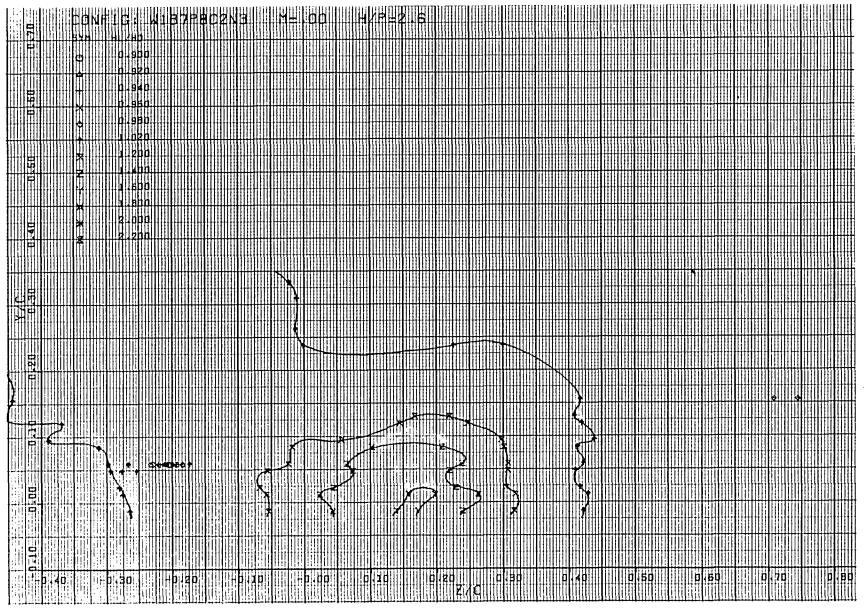


Figure 108. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$ test 23, series 2, run numbers 105 – 111, $\alpha = 0^\circ$

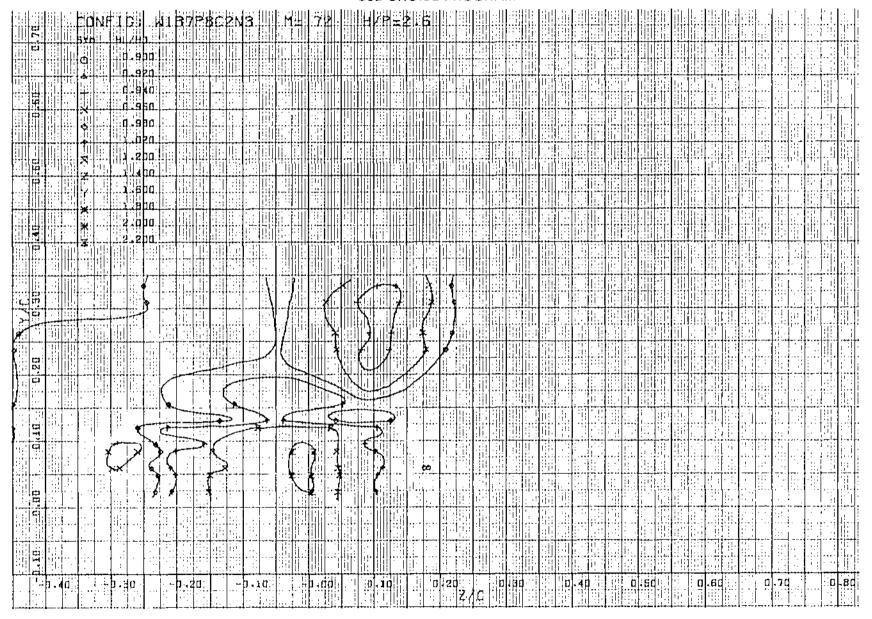


Figure 109. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC}=3.5\times10^6$ Test 23, series 2, run numbers 132 - 137, $\alpha=3^\circ$

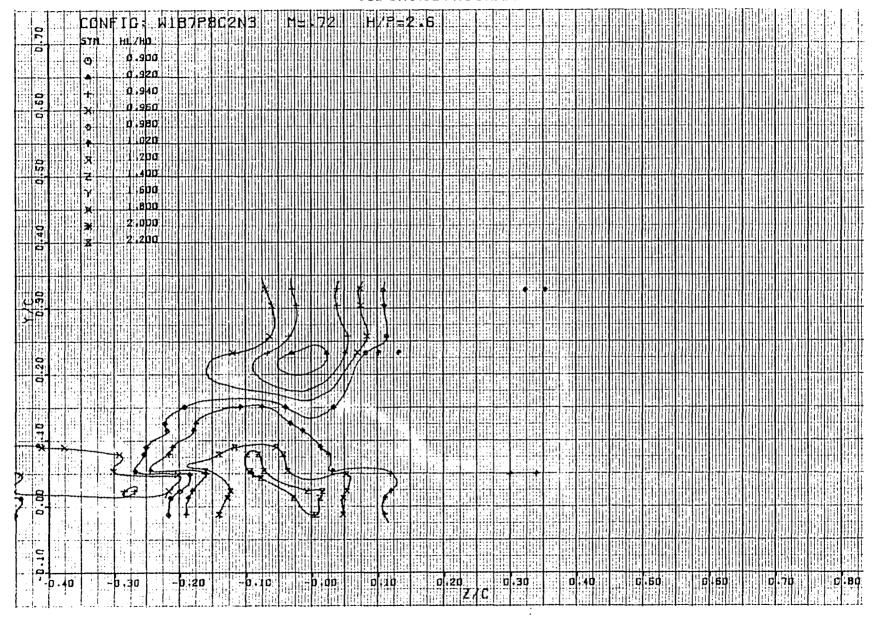


Figure 110. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$, test 23, series 2, run numbers 138 - 144, $\alpha = 3^\circ$

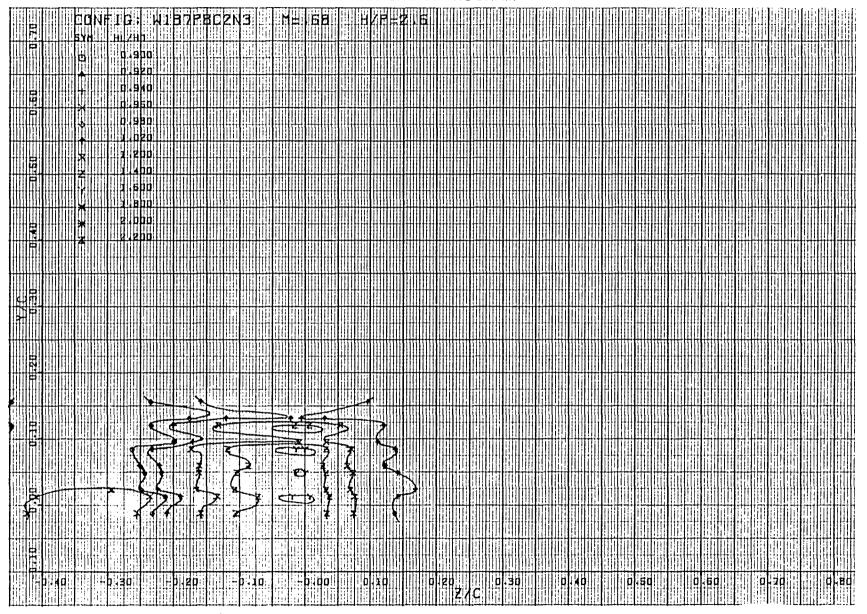


Figure 111. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$, test 23, series 2, run numbers 145 - 149, $\alpha = 3^\circ$

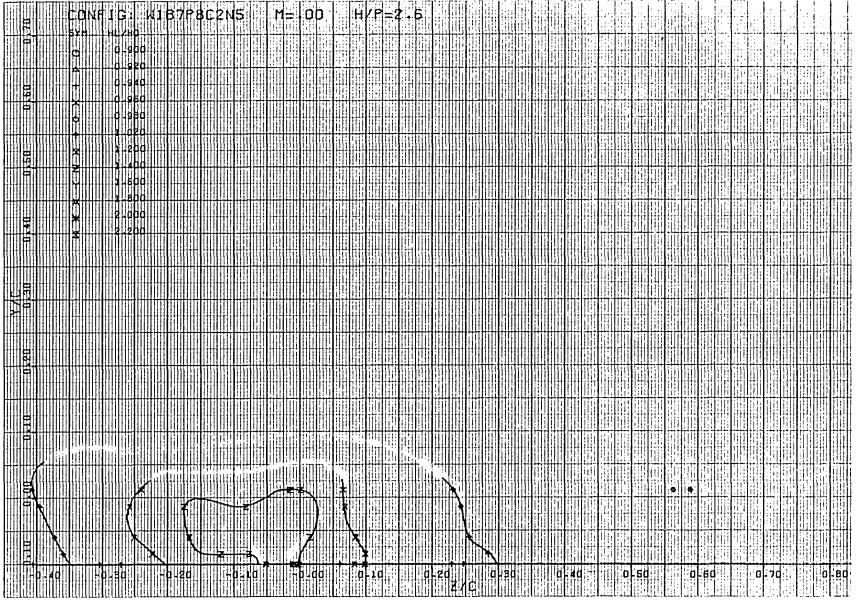


Figure 112. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$, test 23, series 3, run numbers 210 – 213, $\alpha = 0^\circ$

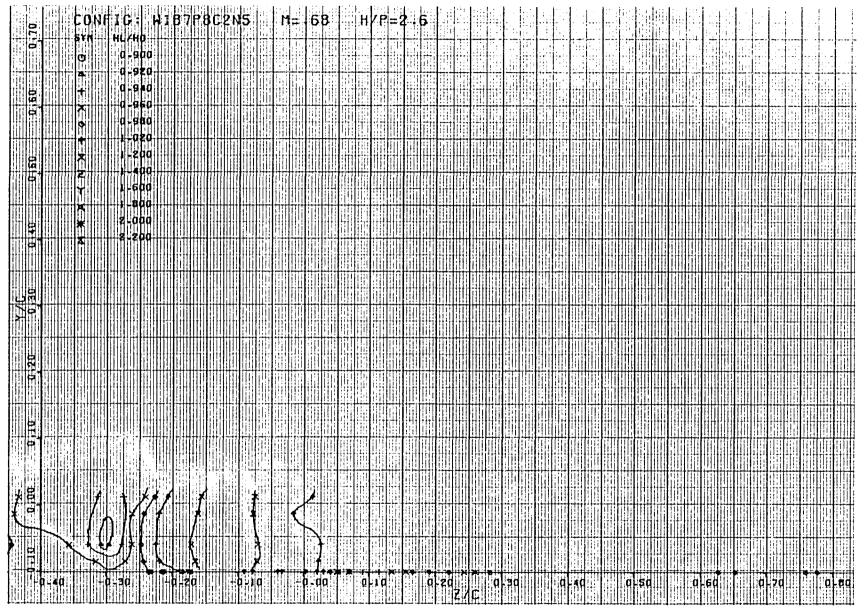


Figure 113. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$, test 23, series 3, run numbers 206 - 209, $\alpha = 3^\circ$

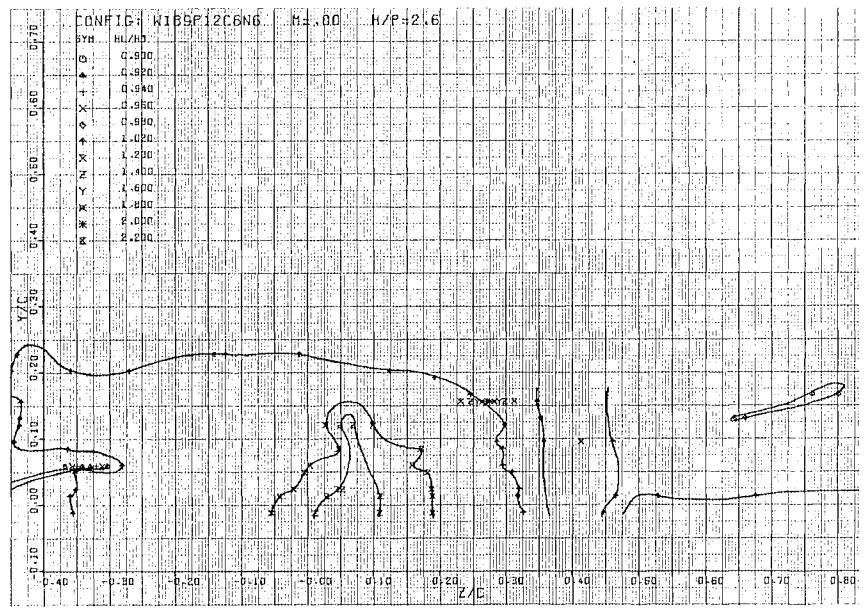


Figure 114. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC}=3.5\times10^6$, test 23, series 4, run numbers 270 - 276, $\alpha=0^\circ$

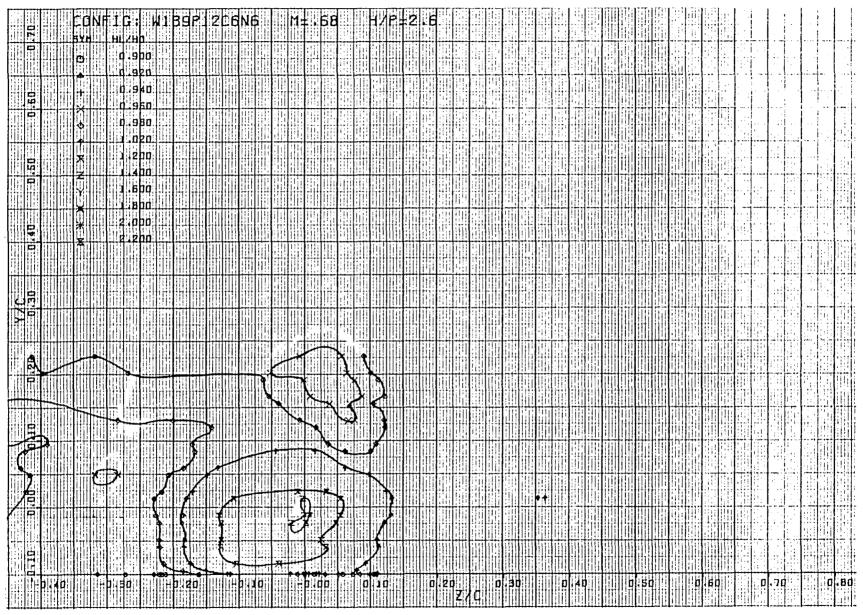


Figure 115. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$, test 23, series 4, run numbers 290 – 302, $\alpha = 3^\circ$

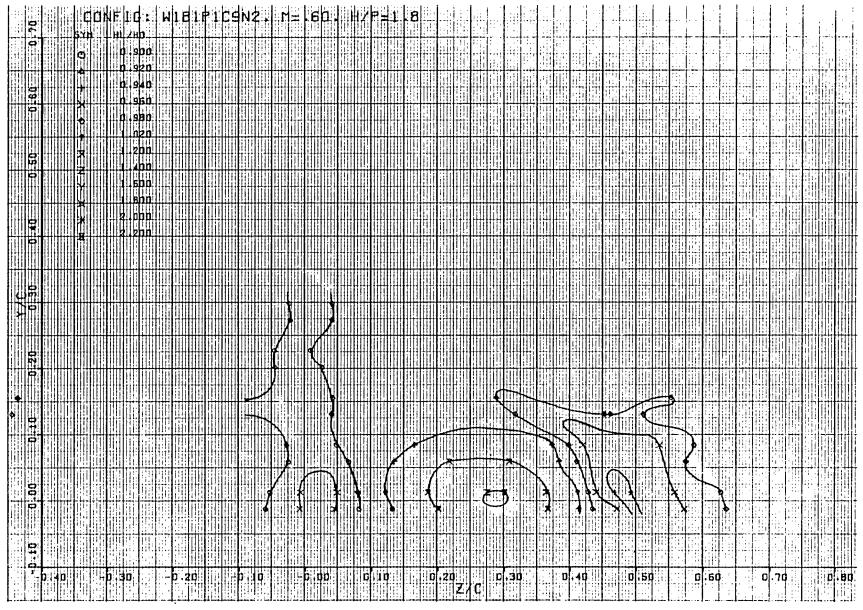


Figure 116. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$, test 23, series 5, run numbers 307 - 311, $\alpha = 2.6^\circ$

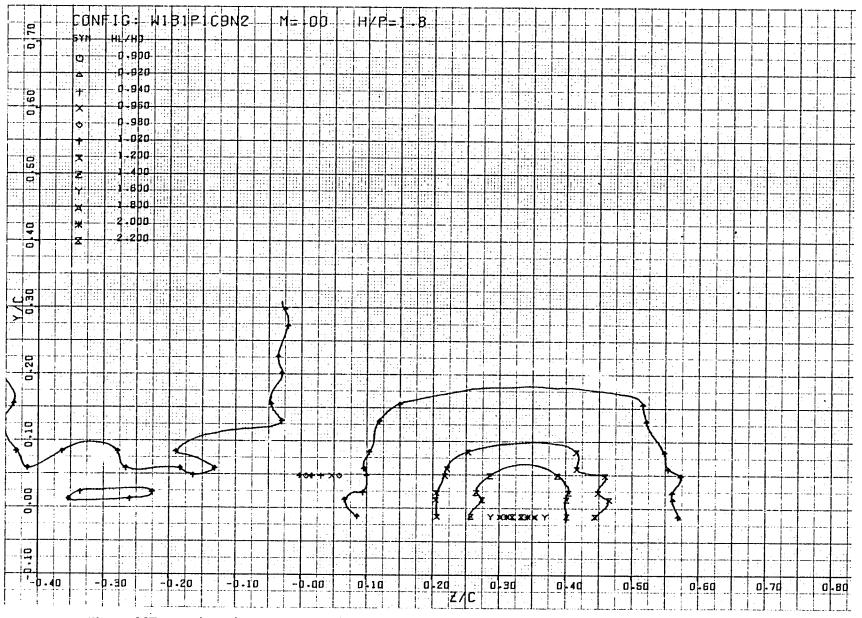


Figure 117. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$, test 23, series 5, run numbers 323-328, $\alpha = 2.6^\circ$

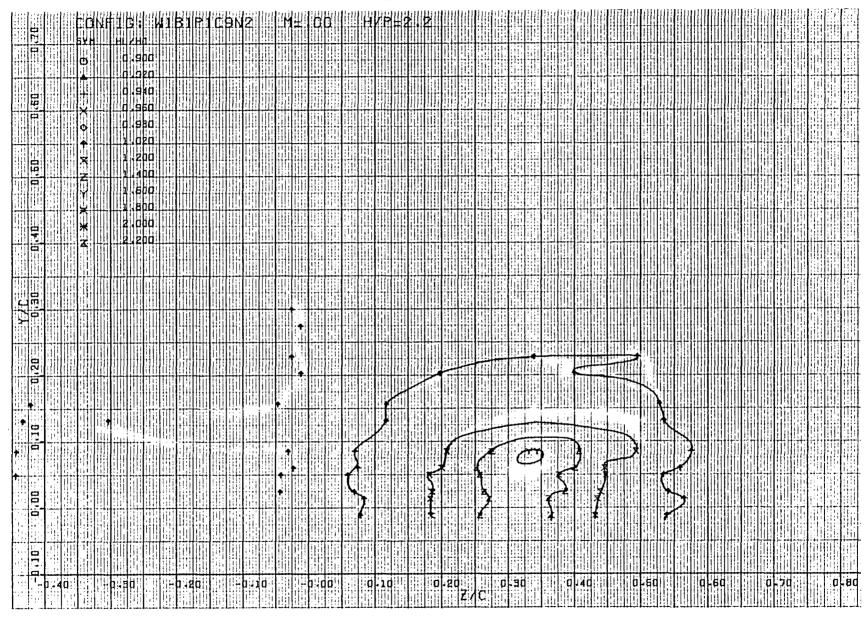


Figure 118. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$, test 23, series 5, run numbers 329 – 334, $\alpha = 2.6^\circ$

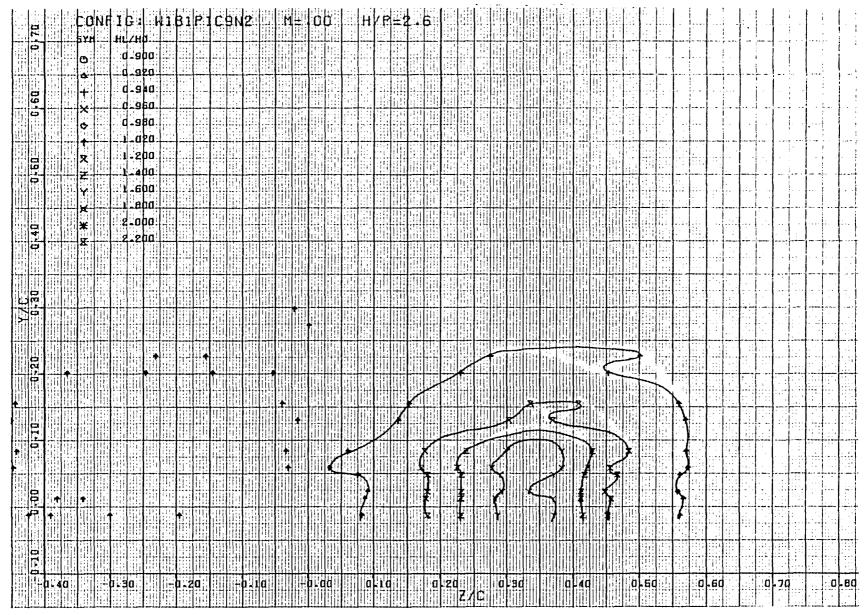


Figure 119. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$, test 23, series 5, run numbers 335-340, $\alpha = 2.6^\circ$

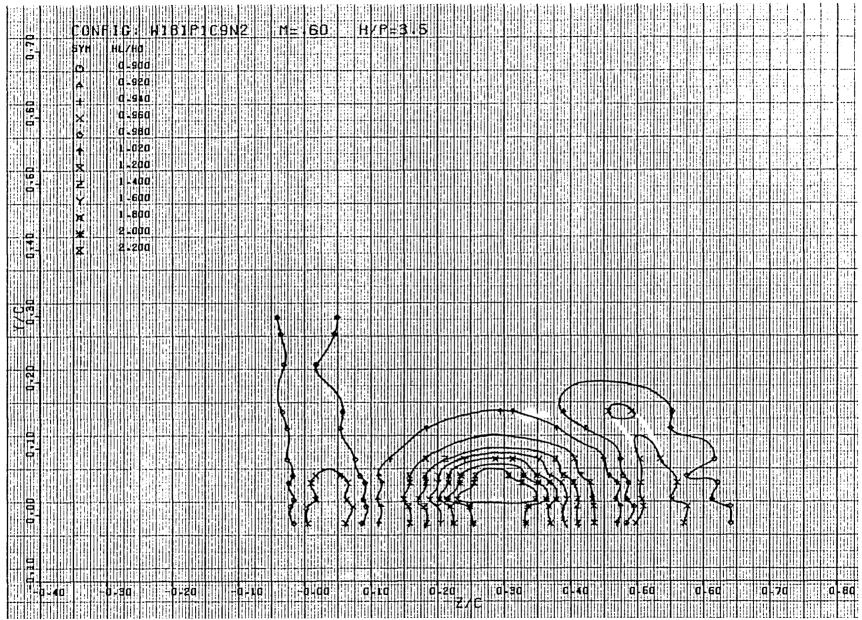


Figure 120. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$, test 23, series 5, run numbers 341-346, $\alpha = 2.6^\circ$

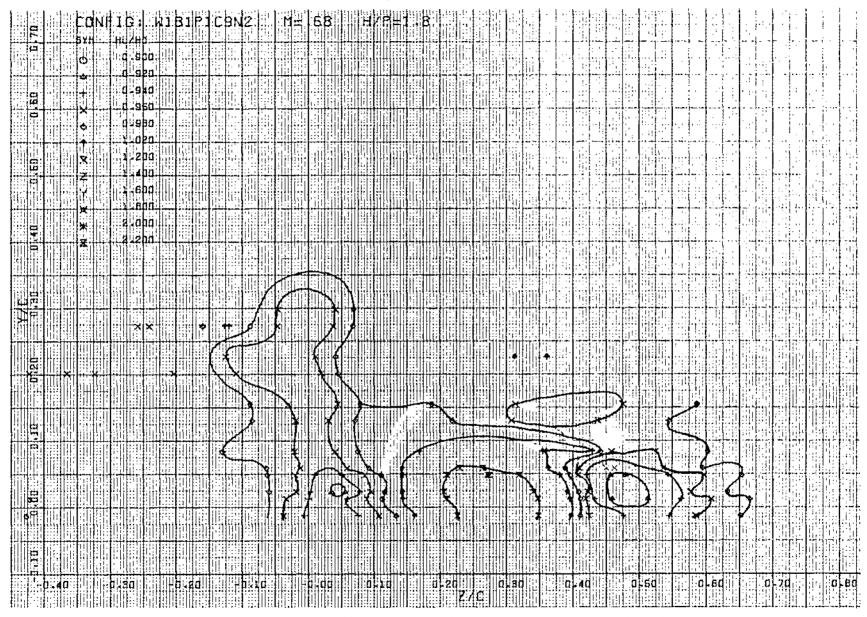


Figure 121. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^{\circ}$, test 23, series 5, run numbers 349 – 354, $\alpha = 2.6^{\circ}$

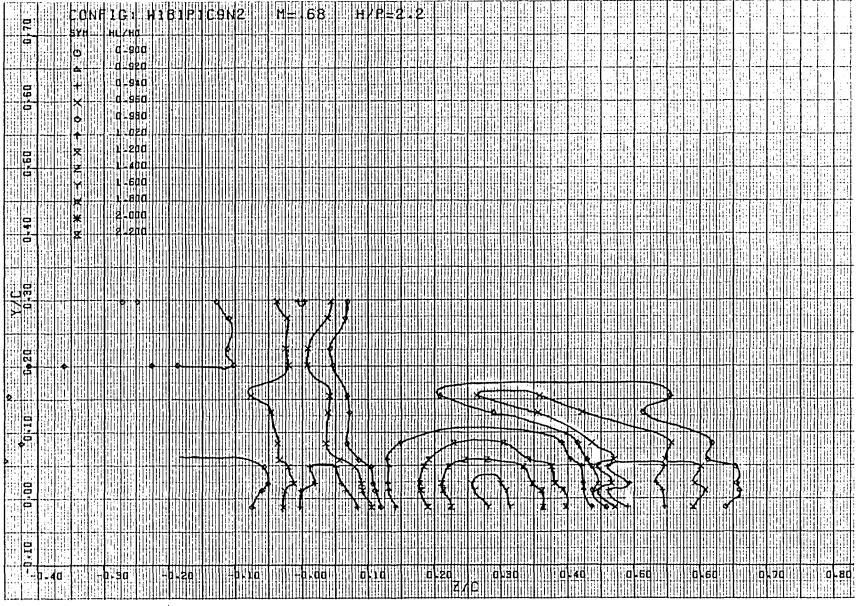


Figure 122. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$, test 23, series 5, run numbers 355-361, $\alpha = 2.6^\circ$

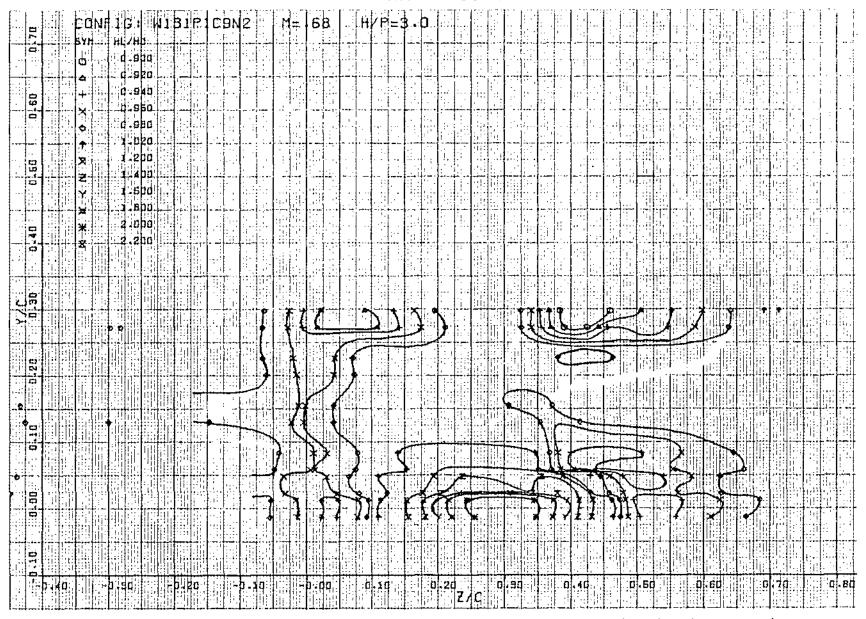


Figure 123. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$, test 23, series 5, run numbers 362-369, $\alpha = 2.6^\circ$

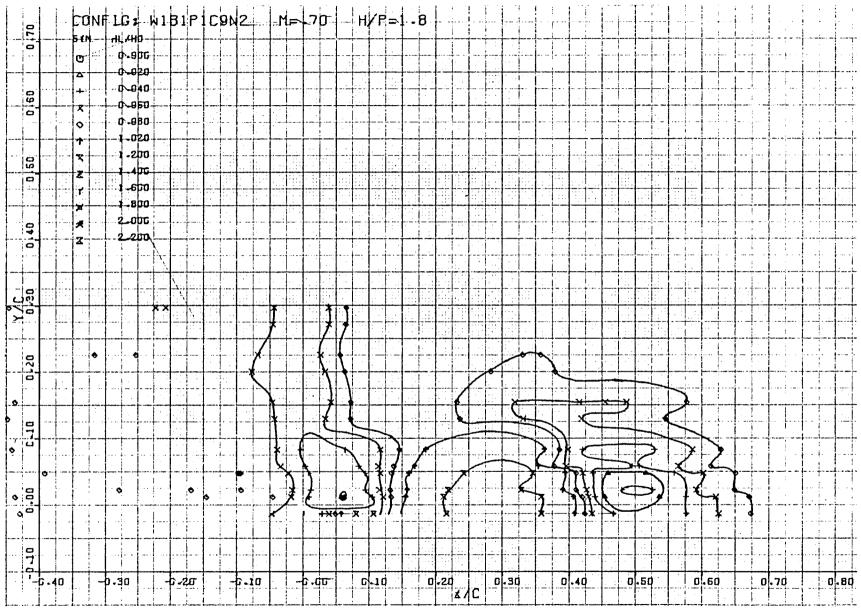


Figure 124. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$, test 23, series 5, run numbers 371-376, $\alpha = 2.6^\circ$

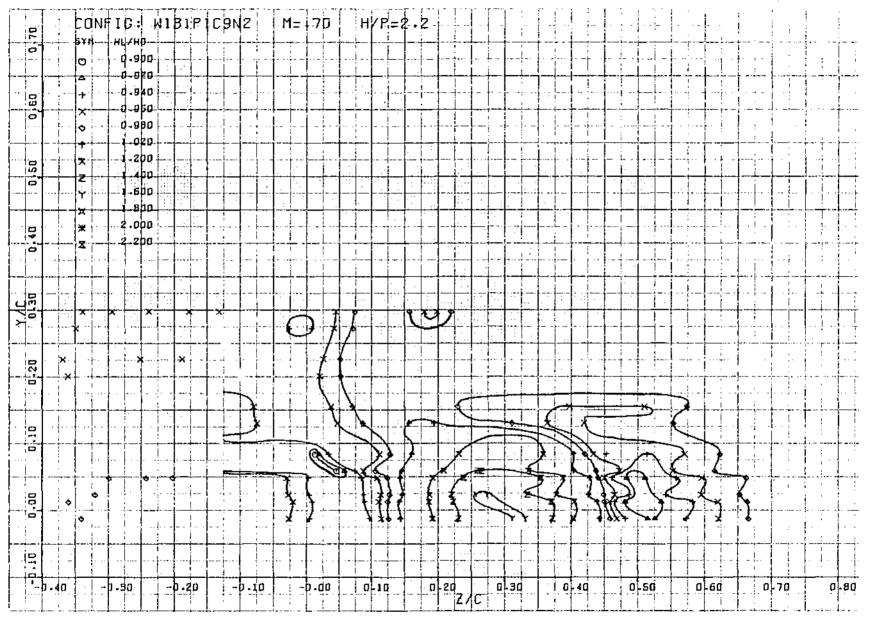


Figure 125. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^{\circ}$, test 23, series 5, run numbers 377 – 382, $\alpha = 2.6^{\circ}$

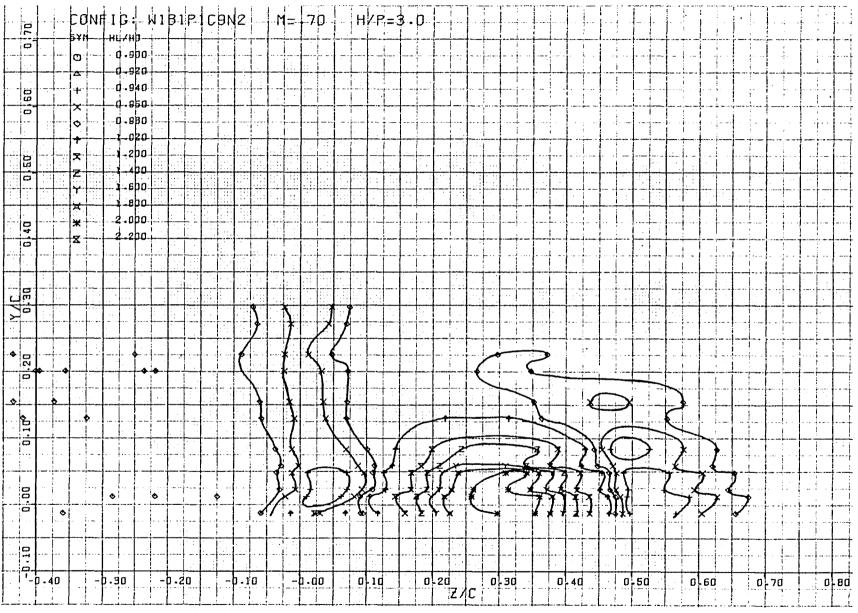


Figure 126. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$, test 23, series 5, run numbers 383-388, $\alpha = 2.6^\circ$

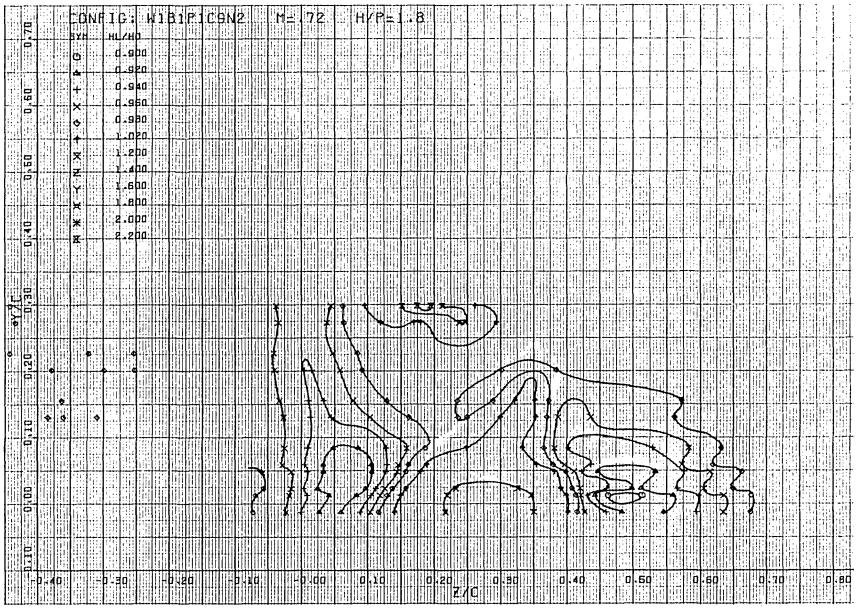


Figure 127. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^{\circ}$, test 23, series 5, run numbers 392-397, $\alpha = 2.6^{\circ}$

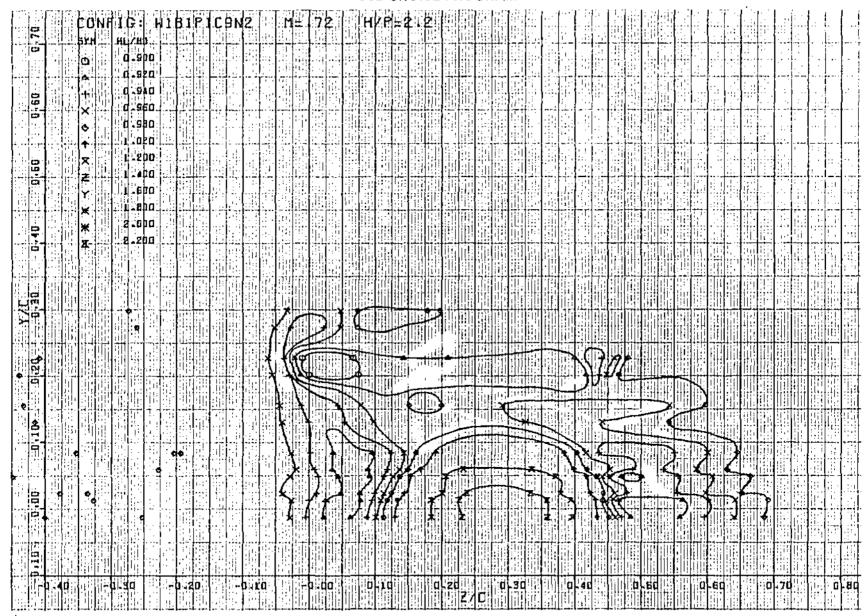


Figure 128. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length of trailing edge, $R_{NC}=3.5\times10^6$, test 23, series 5, run numbers 398-403, $\alpha=2.6^\circ$

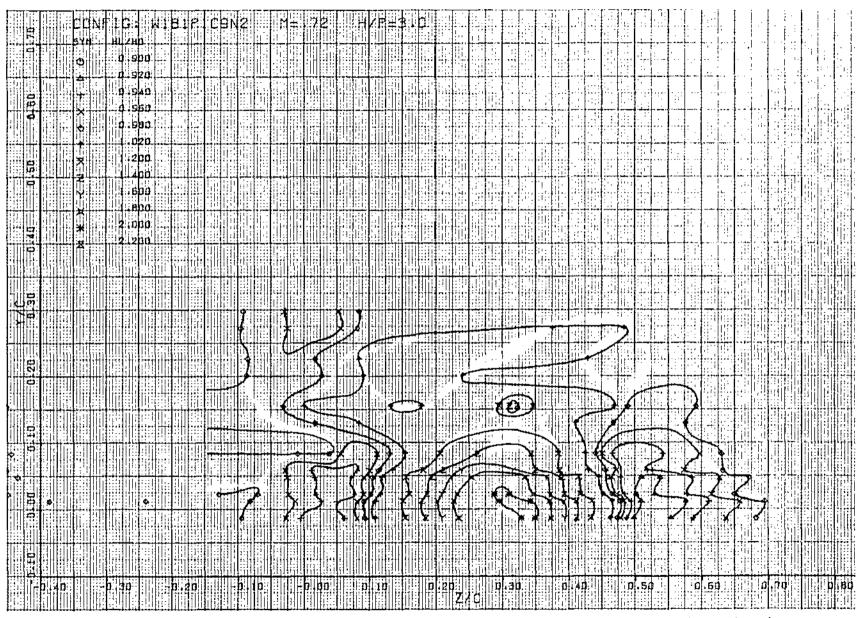


Figure 129. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$, test 23, series 5, run numbers 404 - 409, $\alpha = 2.6^\circ$

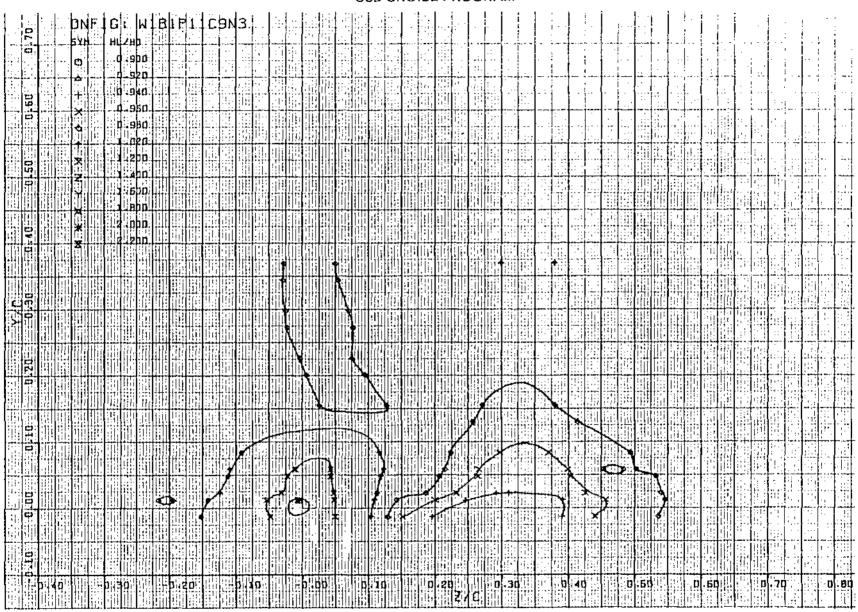


Figure 130. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length of trailing edge, $R_{NC} = 3.5 \times 10^{6}$, test 23, series 5, run numbers 412 - 418, $\alpha = 2.6^{\circ}$

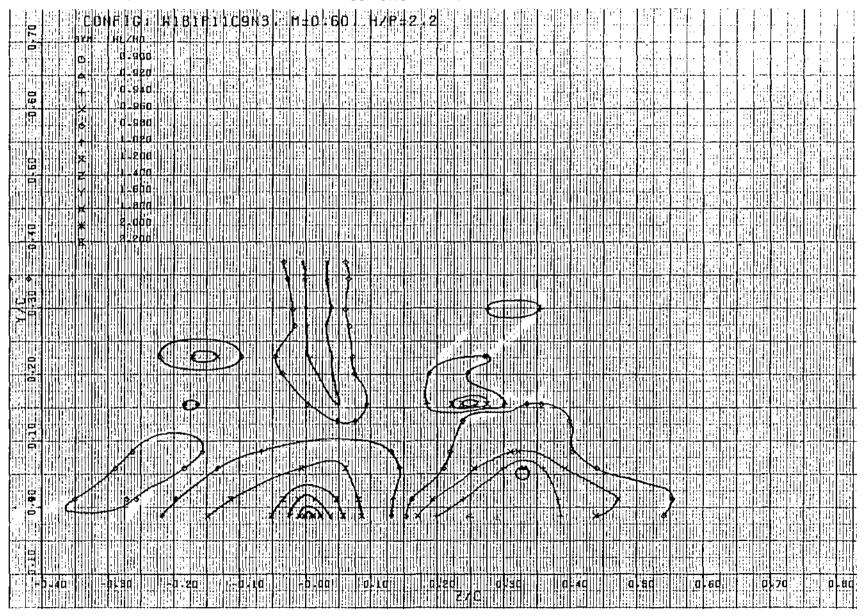


Figure 131. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$, test 23, series 6, run numbers 419 - 424, $\alpha = 2.6^\circ$

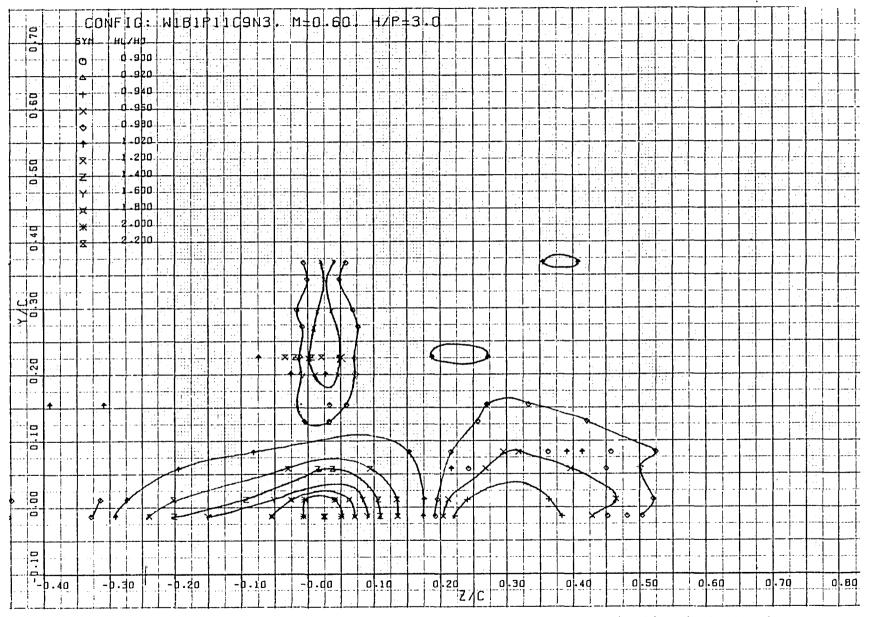


Figure 132. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^{\circ}$, test 23, series 6, run numbers 425 - 433, $\alpha = 2.6^{\circ}$

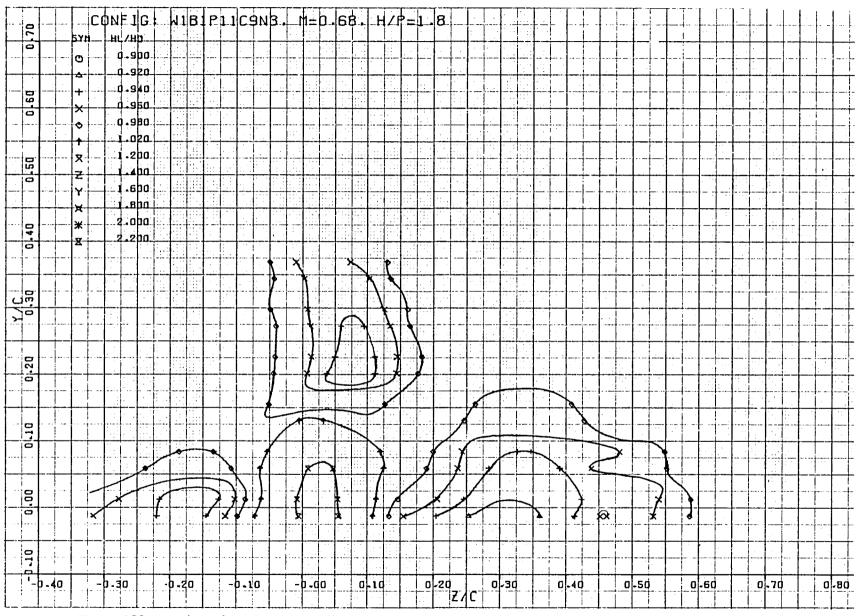


Figure 133. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$, test 23, series 6, run numbers 435 - 444, $\alpha = 2.6^\circ$

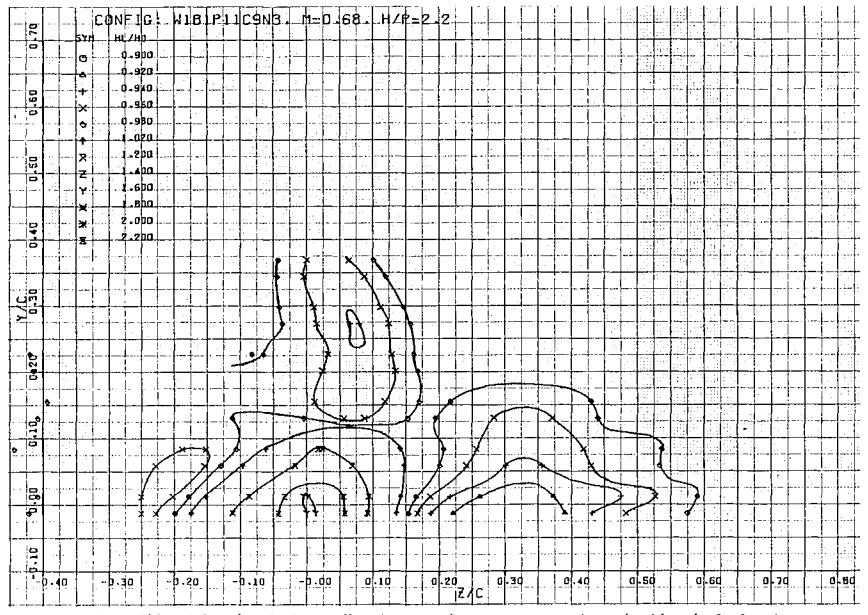


Figure 134. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$, test 23, series 6, run numbers 445 - 450, $\alpha = 2.6^\circ$

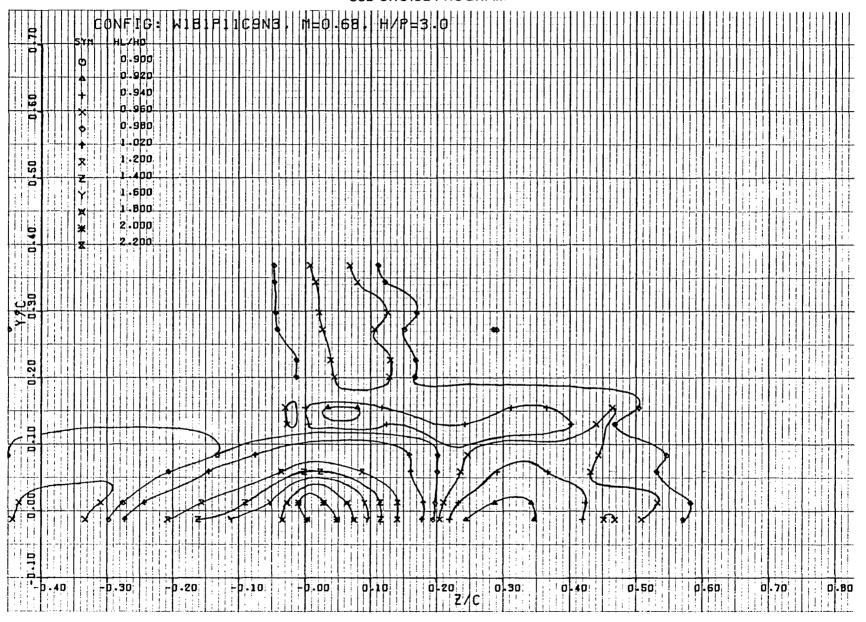


Figure 135. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^{\circ}$, test 23, series 6, run numbers 451 - 456, $\alpha = 2.6^{\circ}$

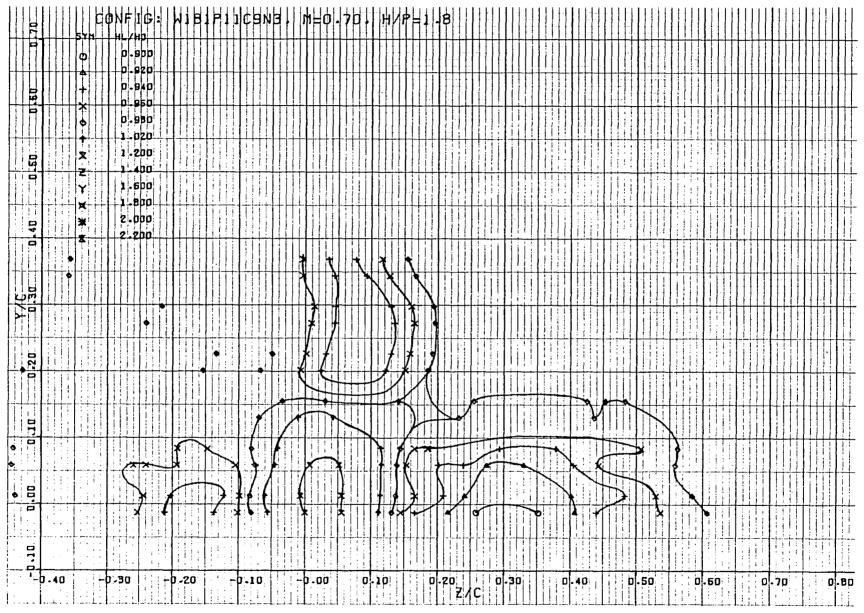


Figure 136. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$, test 23, series 6, run numbers 457 - 462, $\alpha = 2.6^\circ$

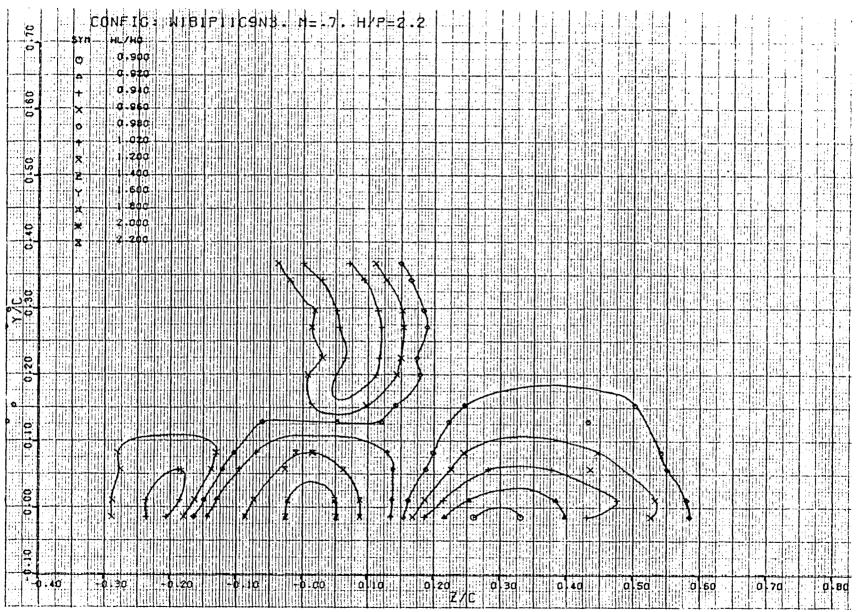


Figure 137. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$, test 23, series 6, run numbers 464 - 469, $\alpha = 2.6^\circ$

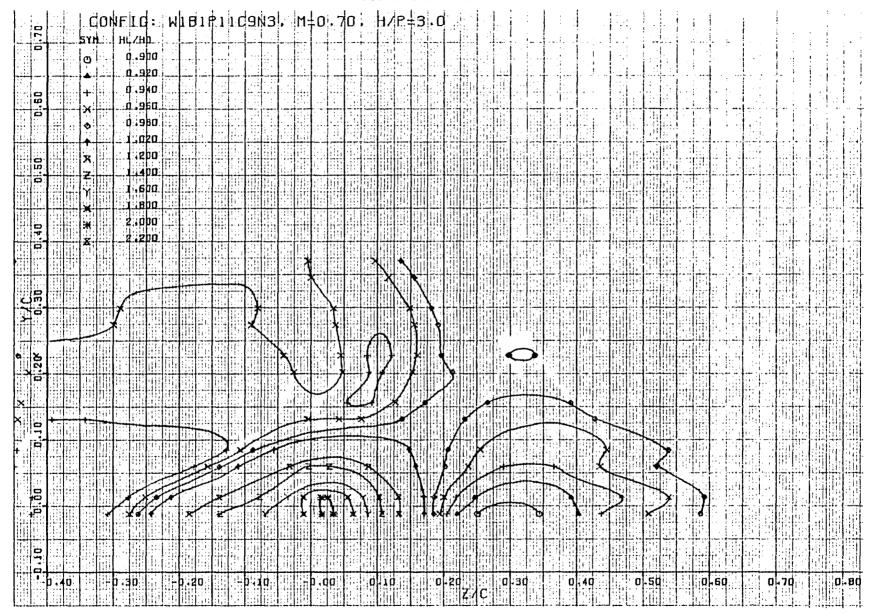


Figure 138. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^{\circ}$, test 23, series 6, run numbers 470 - 475, $\alpha = 2.6^{\circ}$

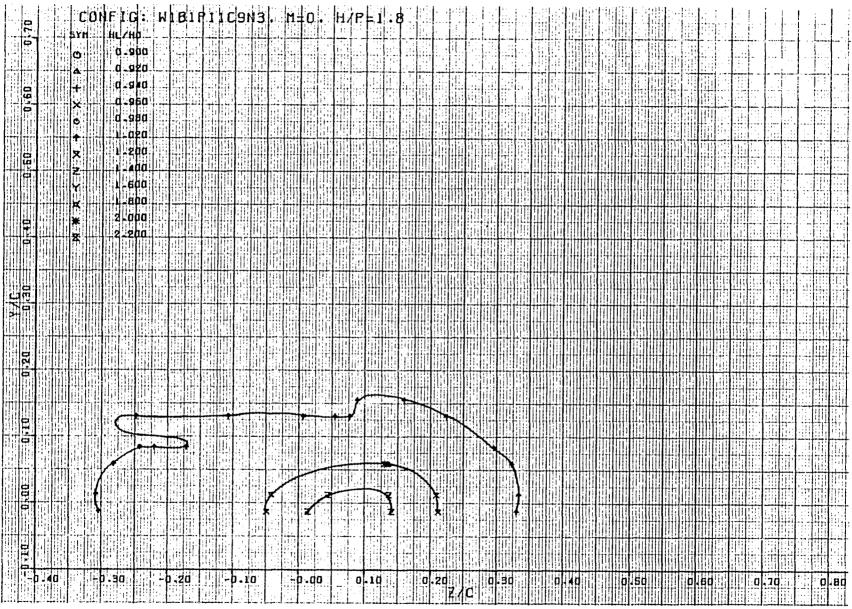


Figure 139. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$, test 23, series 6, run numbers 476 – 481, $\alpha = 2.6^\circ$

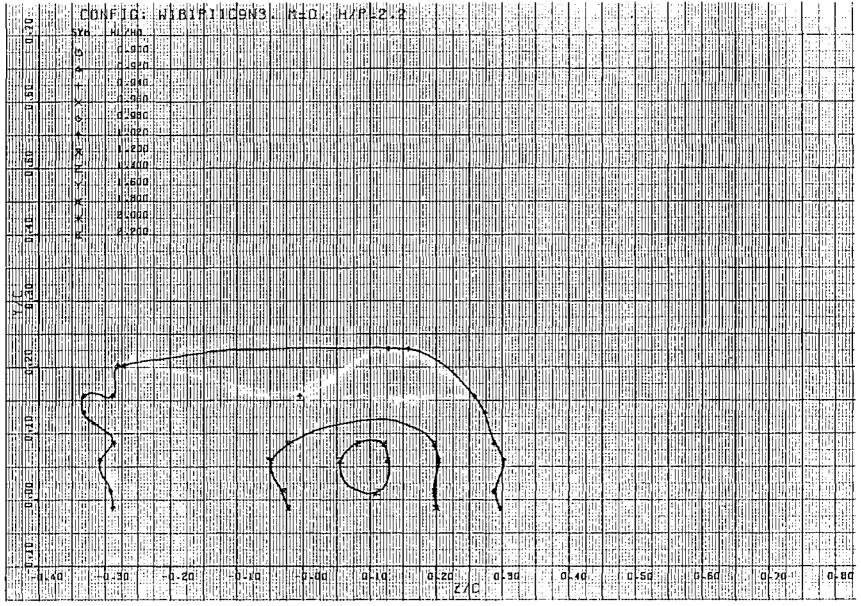


Figure 140. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^{6}$, test 23, series 6, run numbers 482 - 487, $\alpha = 2.6^{\circ}$

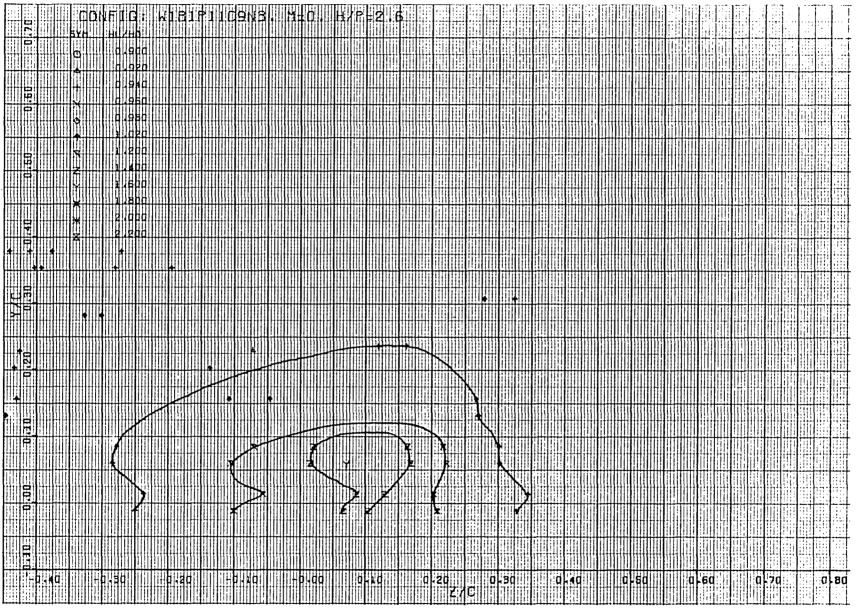


Figure 141. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$, test 23, series 6, run numbers 488 - 493, $\alpha = 2.6^\circ$

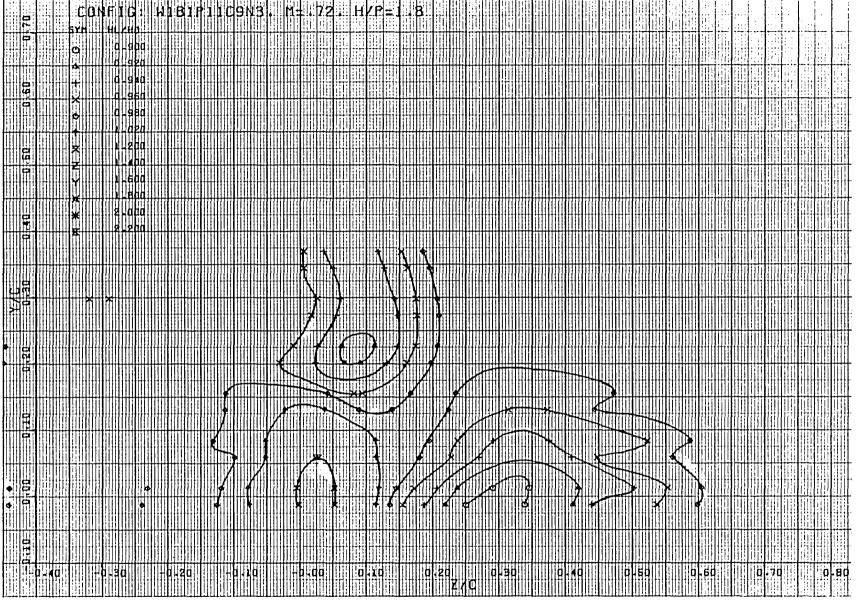


Figure 142. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$, test 23, series 6, run numbers 495 - 501, $\alpha = 2.6^\circ$

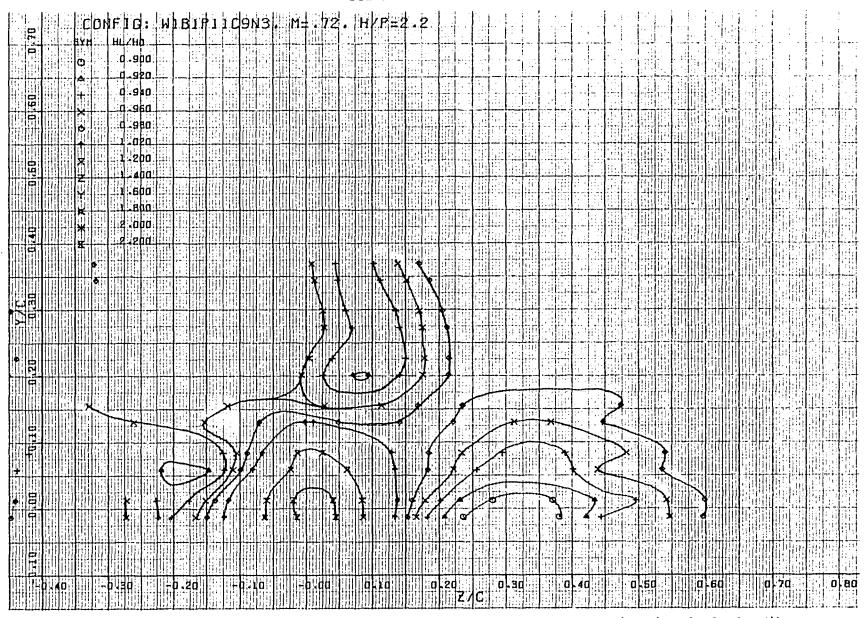


Figure 143. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$, test 23, series 6, run numbers 502 - 507, $\alpha = 2.6^\circ$

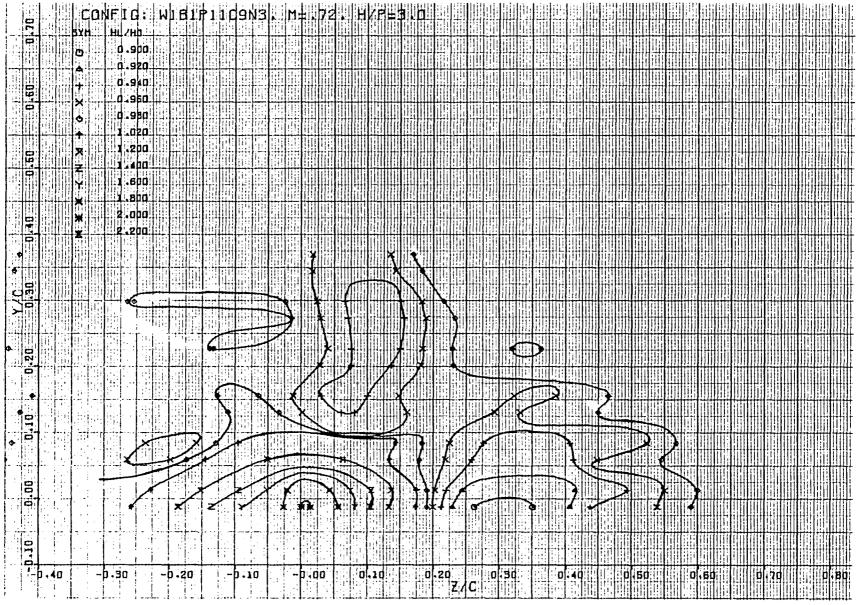


Figure 144. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$, test 23, series 6, run numbers 508 - 517, $\alpha = 2.6^\circ$

6.0 SWEPT WING TEST RESULTS

The presentation of the swept wing pressure test results is divided into two parts. These are the model pressure distributions and the wake pressure patterns; they are described separately in the following two sub-sections.

6.1 Model Pressure Distributions

Surface static pressure data for each of the configurations that were ran in the swept wing pressure tests are presented in Figures 145 through 188. The format is the same as was employed for Figures 45 through 104 in Section 5. The data begin with the clean, swept wing, which is followed by a pylon-mounted flow-through nacelle with the circular nozzle N_2 . Single and dual versions of N_8^{-1} and N_8^{-2} are then presented. Finally, data for the AR = 6 nozzle, N_{13} , are shown. All data in this series are presented at a Reynolds' number of 3.5 million based on wing chord.

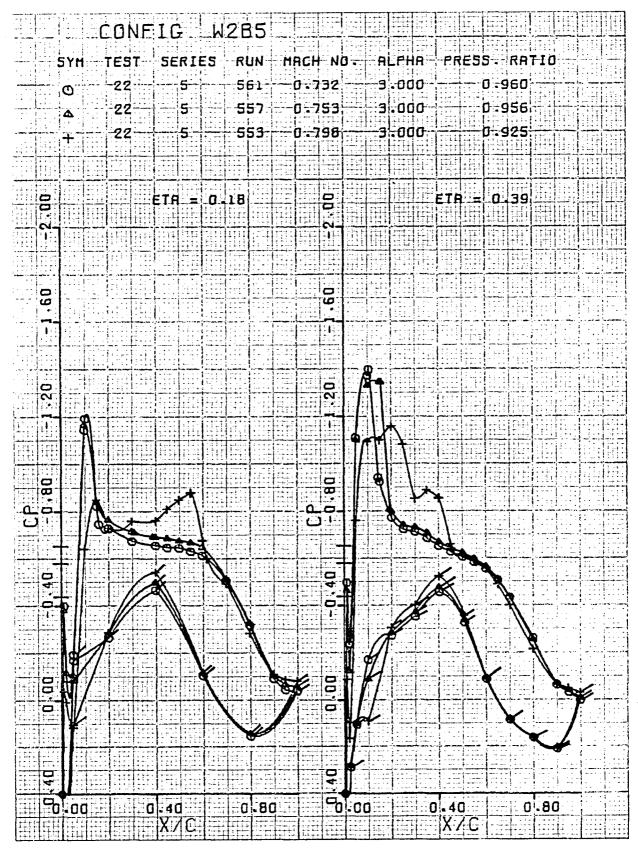


Figure 145. Clean, swept wing pressure distribution, effect of M_{∞} , η = 0.18, 0.39

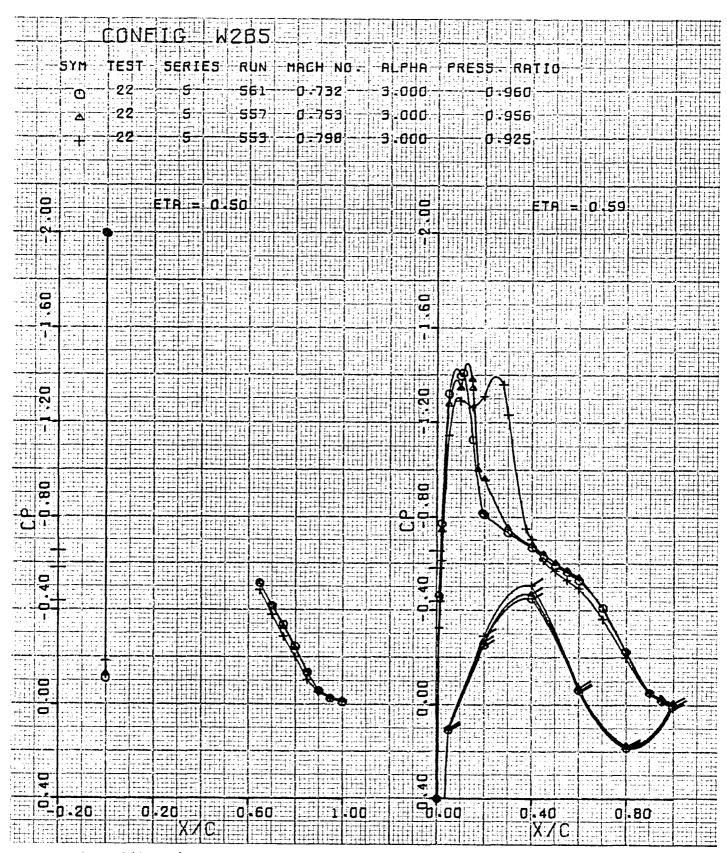


Figure 146. Clean, swept wing pressure distribution, effect of M_{∞} , η = 0.50, 0.59

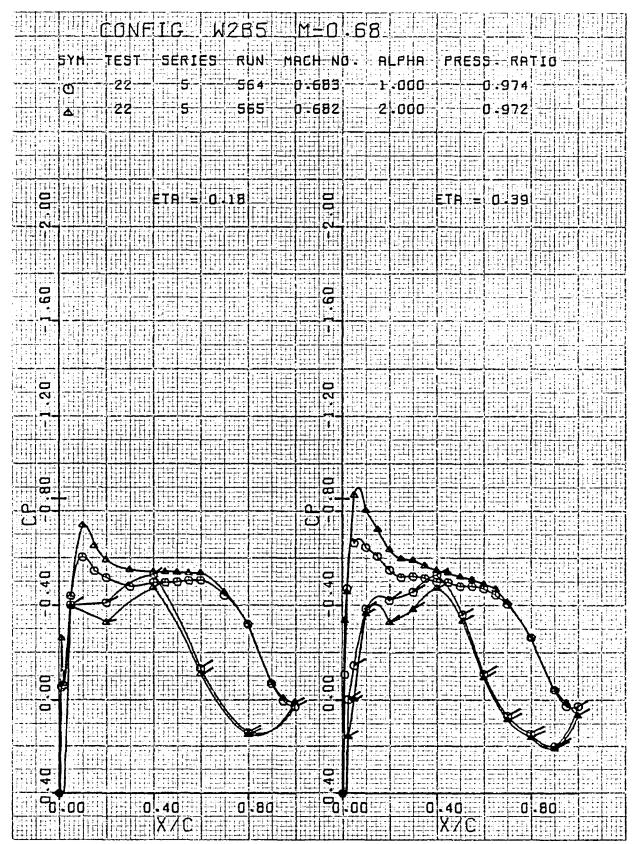


Figure 147. Clean, swept wing pressure distribution, effect of α , $M_{\infty} = 0.68$, $\eta = 0.18$, 0.39

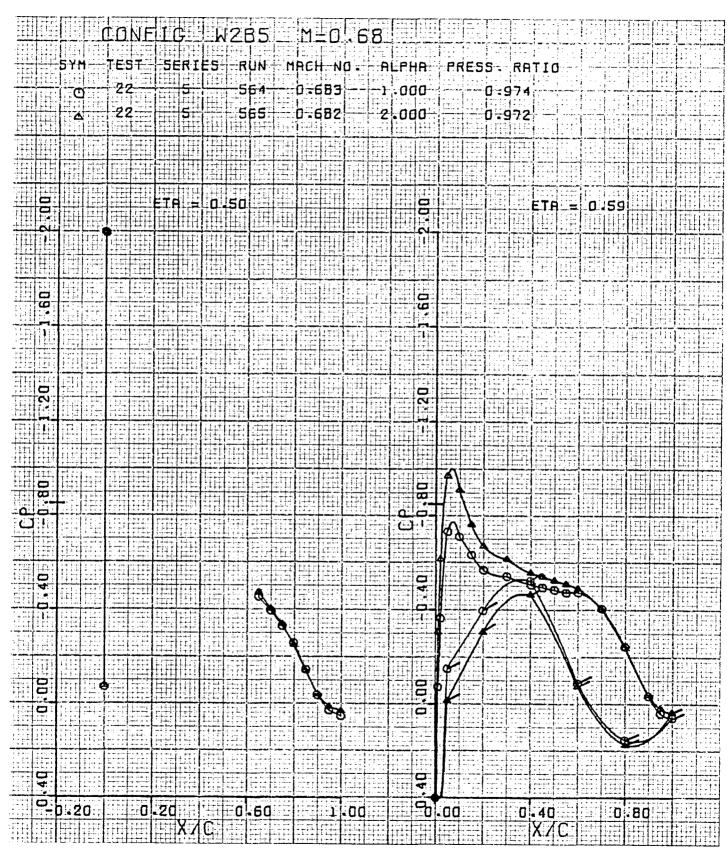


Figure 148. Clean, swept wing pressure distribution, effect of α , $M_{\infty}=0.68$, $\eta=0.50,\ 0.59$

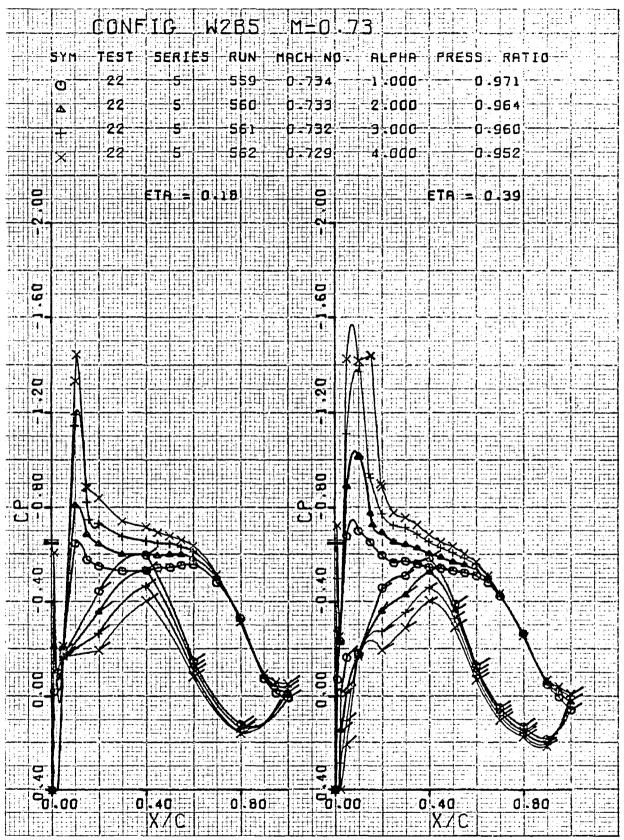


Figure 149. Clean, swept wing pressure distribution, effect of α , $M_{\infty} = 0.73$, $\eta = 0.18$, 0.39

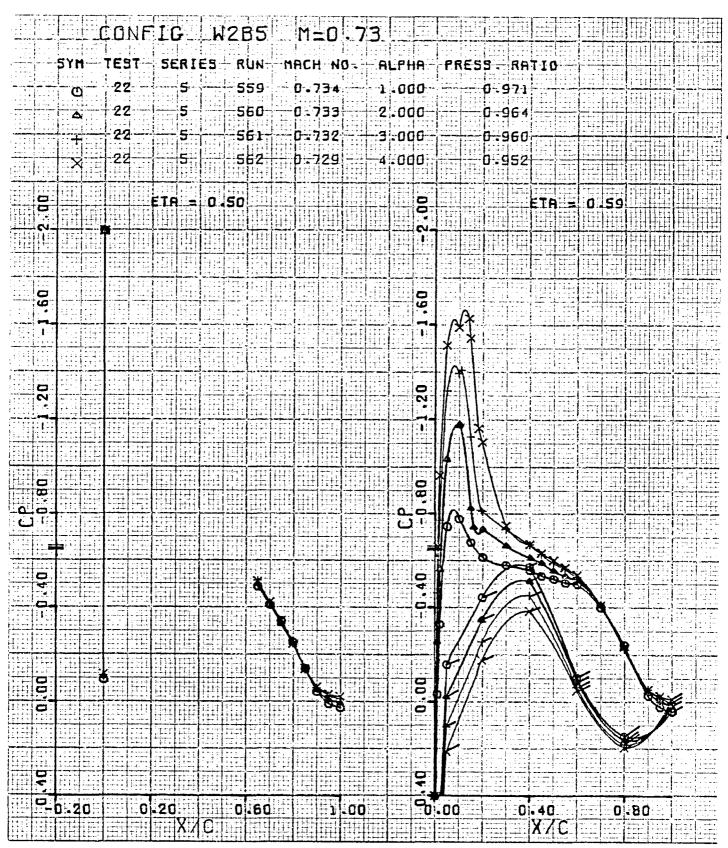


Figure 150. Clean, swept wing pressure distribution, effect of α , $M_{\infty}=0.73$, $\eta=0.50$, 0.59

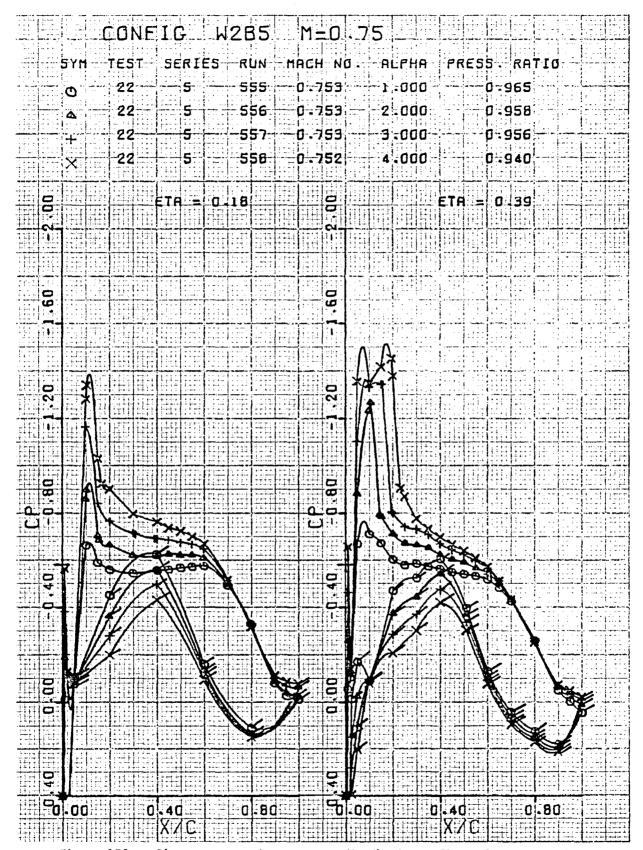


Figure 151. Clean, swept wing pressure distribution, effect of α , $M_{\infty}=0.75$, $\eta=0.18,\,0.39$

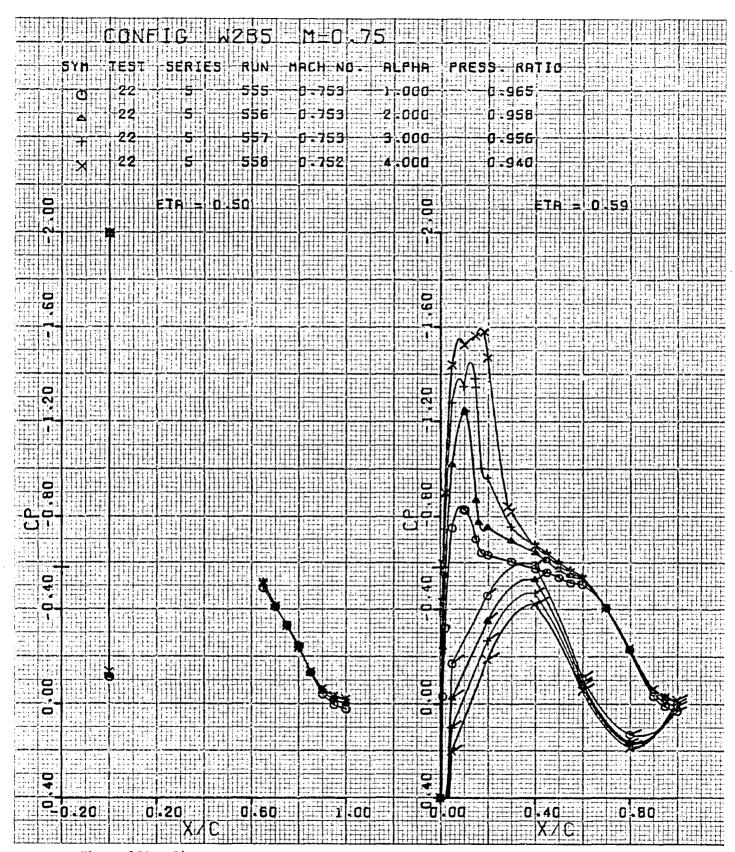


Figure 152. Clean, swept wing pressure distribution, effect of α , M_{∞} = 0.75, η = 0.50, 0.59

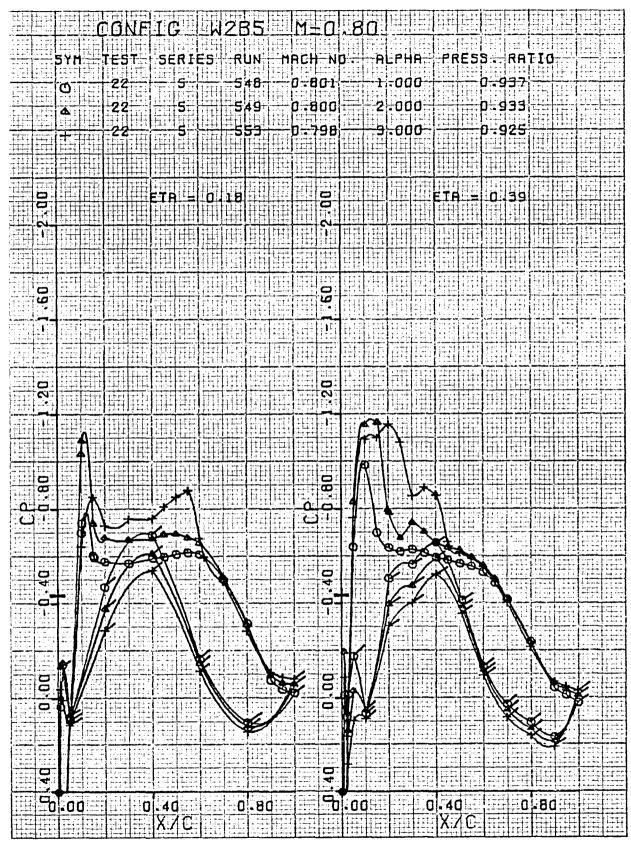


Figure 153. Clean, swept wing pressure distribution, effect of α , $M_{\infty} = 0.80$, $\eta = 0.18$, 0.39

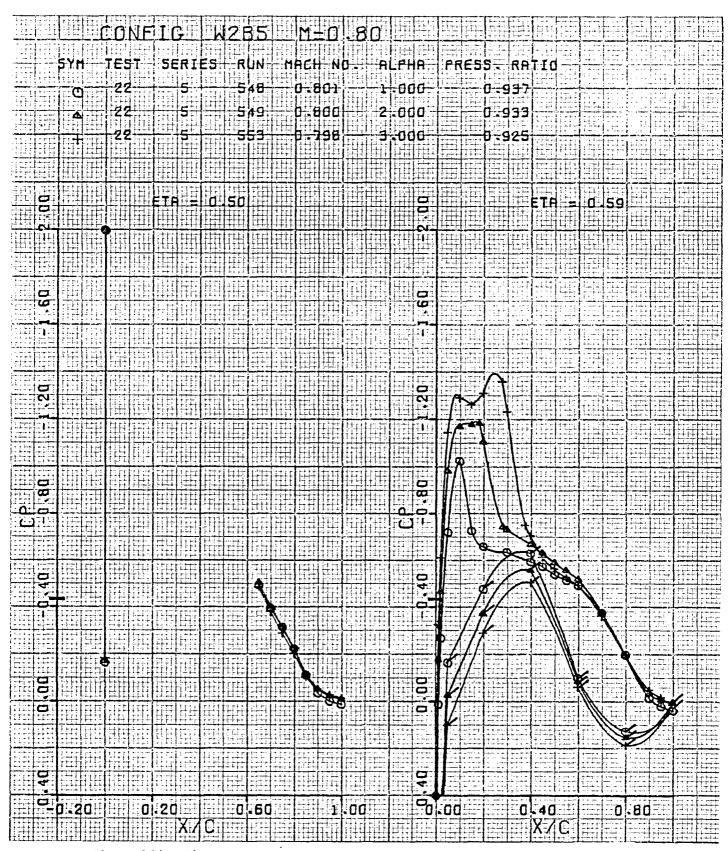


Figure 154. Clean, swept wing pressure distribution, effect of α , $M_{\infty} = 0.80$, $\eta = 0.50$, 0.59

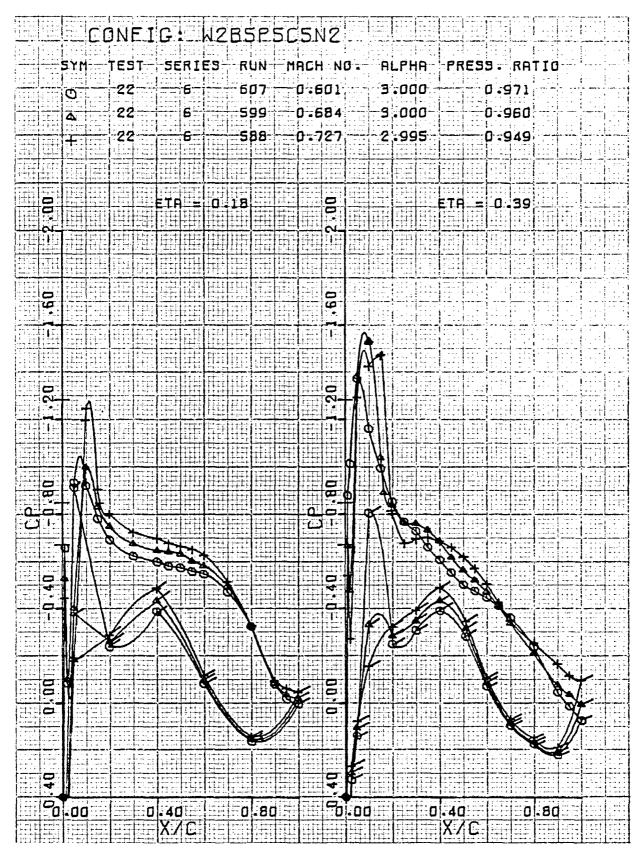


Figure 155. Wing pressure distribution, effect of Mach number, nozzle N_2 , $\eta = 0.18, 0.39$

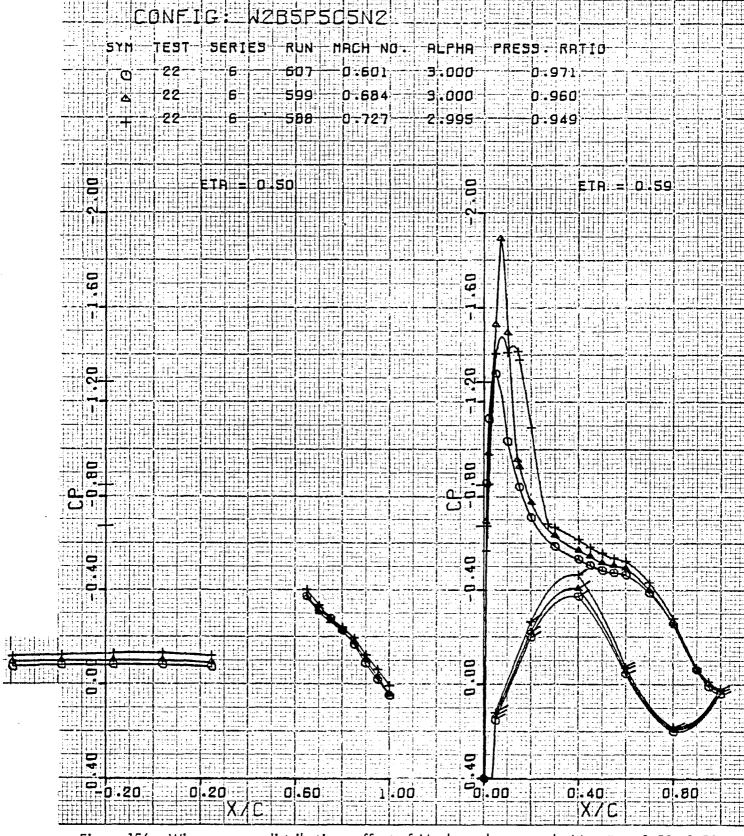


Figure 156. Wing pressure distribution, effect of Mach number, nozzle N_2 , η = 0.50, 0.59

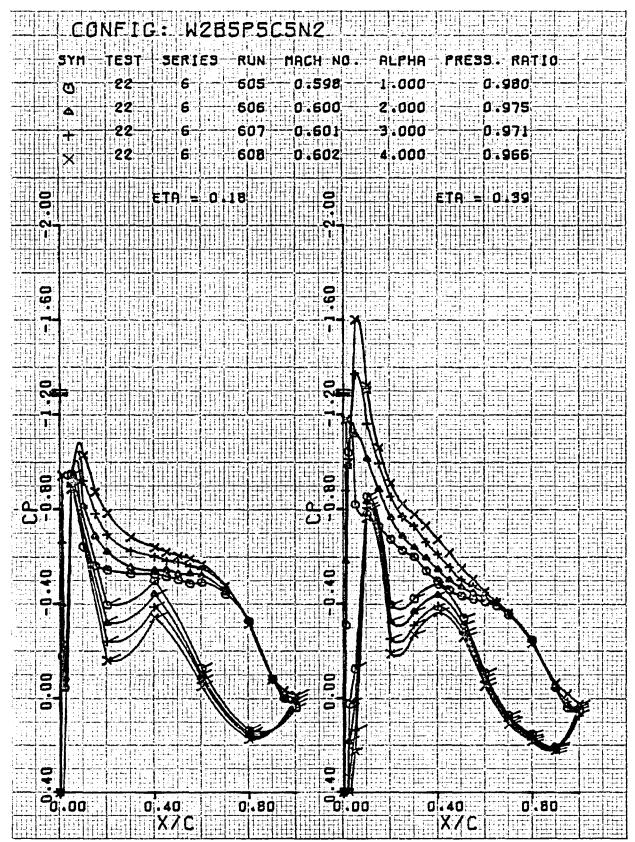


Figure 157. Wing pressure distribution, effect of α , nozzle N₂, M_{∞} = 0.60, η = 0.18, 0.39

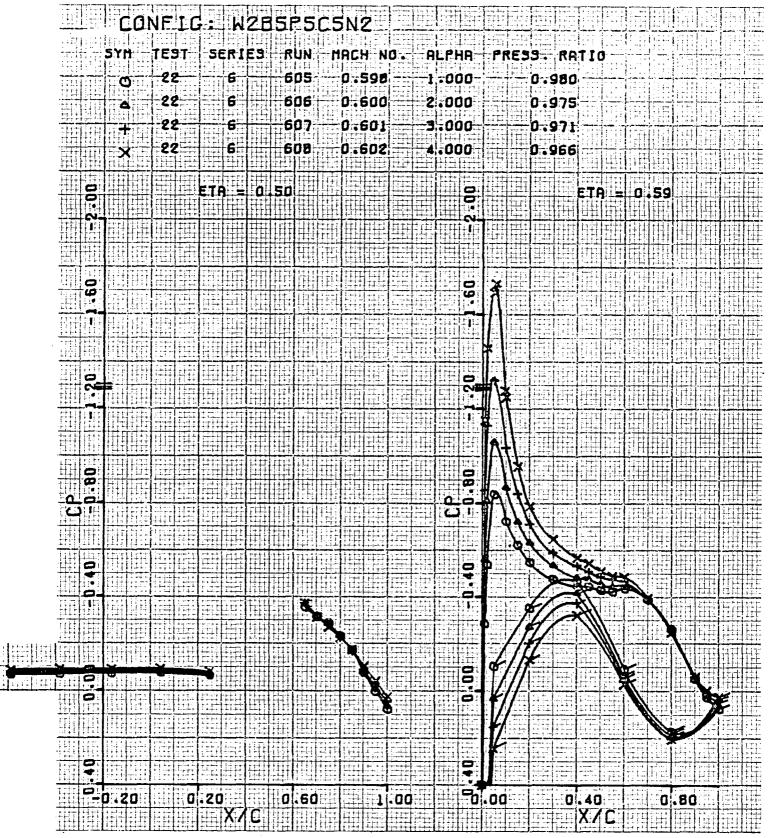


Figure 158. Wing pressure distribution, effect of α , nozzle N₂ , M_{∞} = 0.60, η = 0.50, 0.59

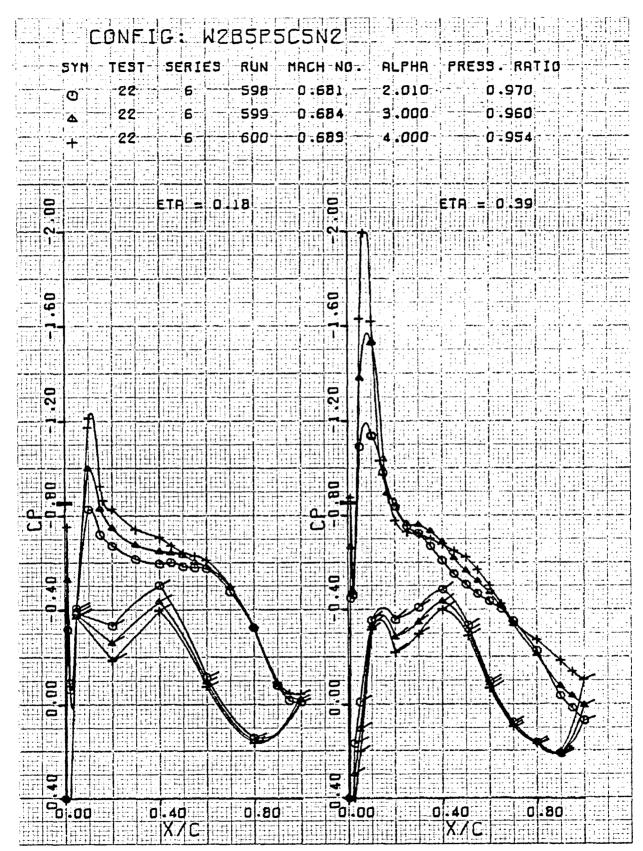


Figure 159. Wing pressure distribution, effect of α , nozzle N₂ , M_{∞} = 0.68, η = 0.18, 0.39

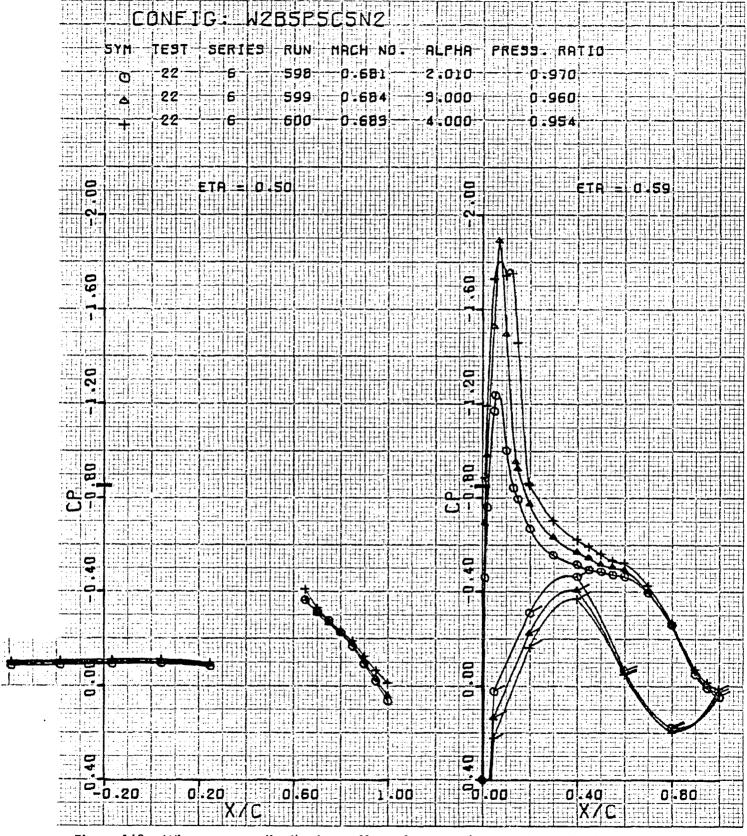


Figure 160. Wing pressure distribution, effect of α , nozzle N₂, M_{∞} = 0.68, η = 0.50, 0.59

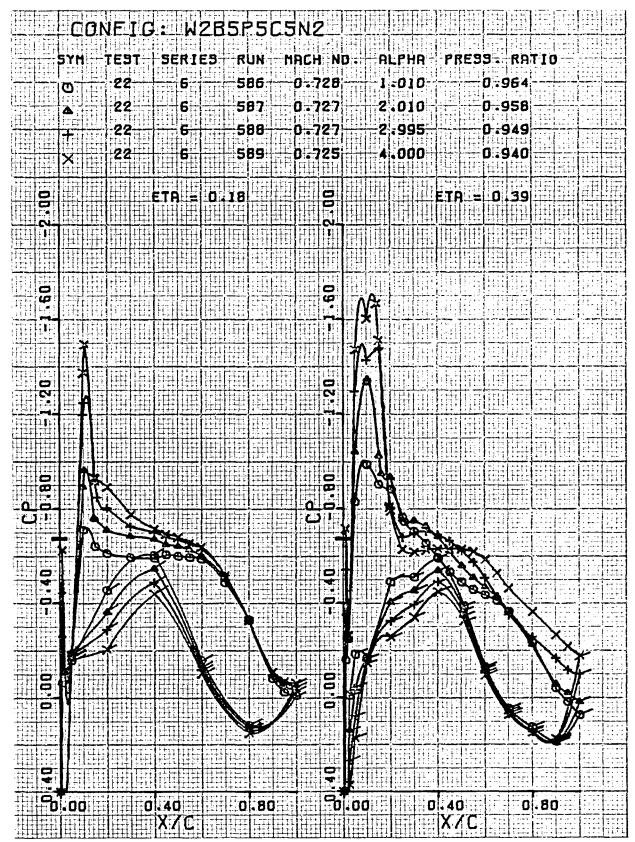
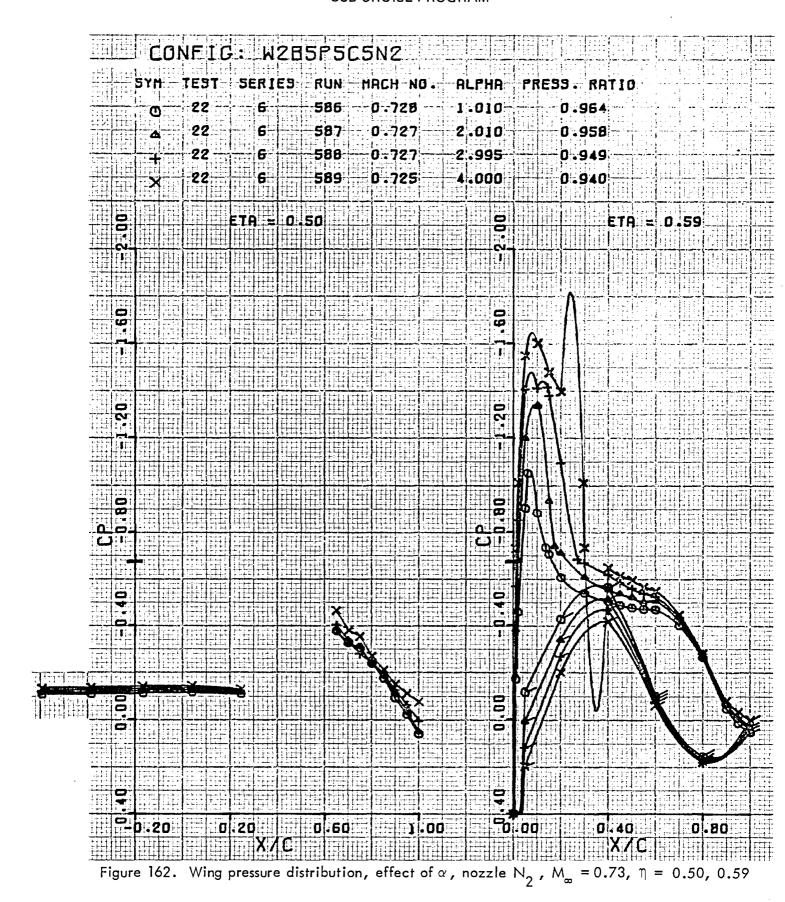


Figure 161. Wing pressure distribution, effect of α , nozzle N₂, M_{∞} = 0.73, η = 0.18, 0.39



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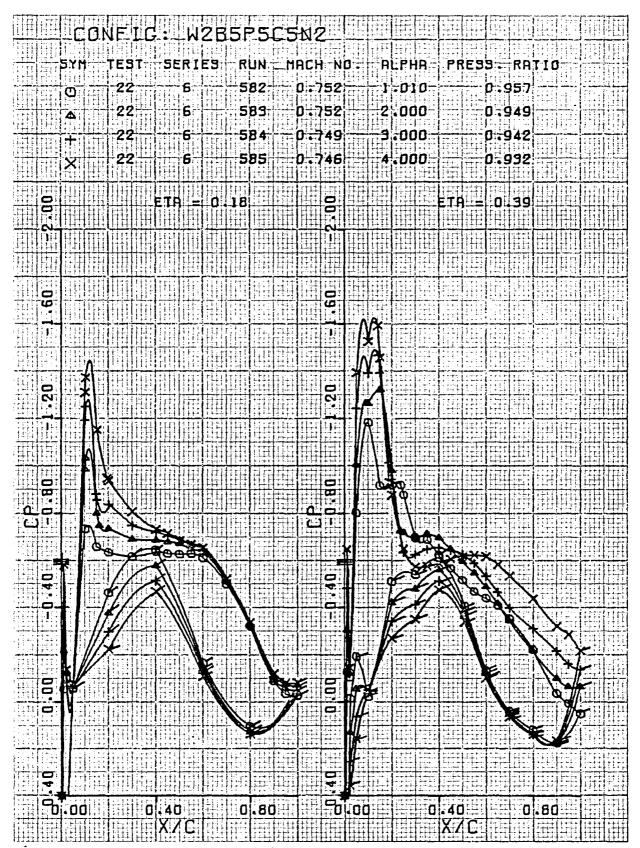


Figure 163. Wing pressure distribution, effect of α , nozzle N₂, M_{∞} = 0.75, η = 0.18, 0.39

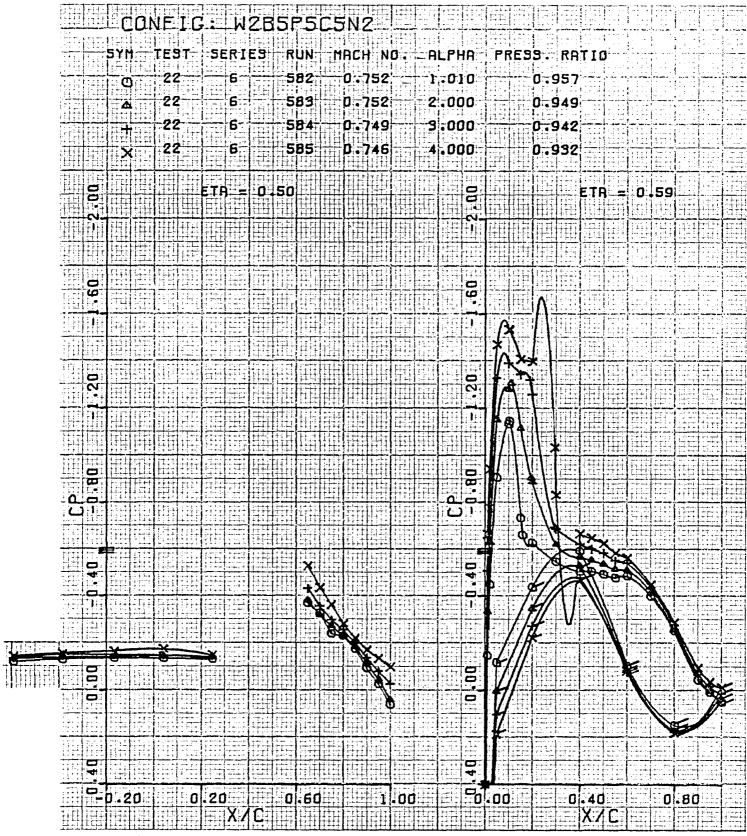


Figure 164. Wing pressure distribution, effect of α , nozzle N_2 , M_{∞} = 0.75, η = 0.50, 0.59

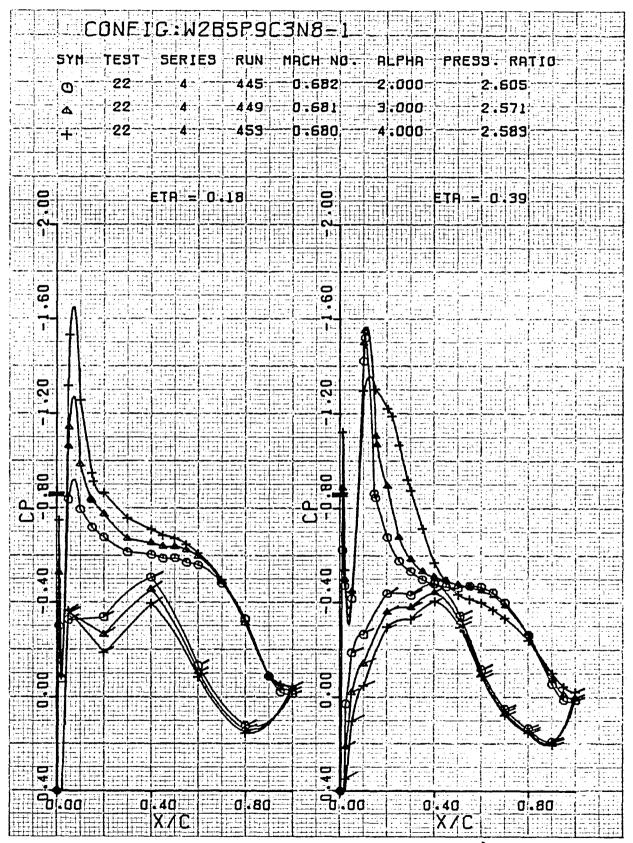


Figure 165. Wing pressure distribution, effect of α , nozzle N_8^1 , $M_{\infty} = 0.68$, $\eta = 0.18$, 0.39

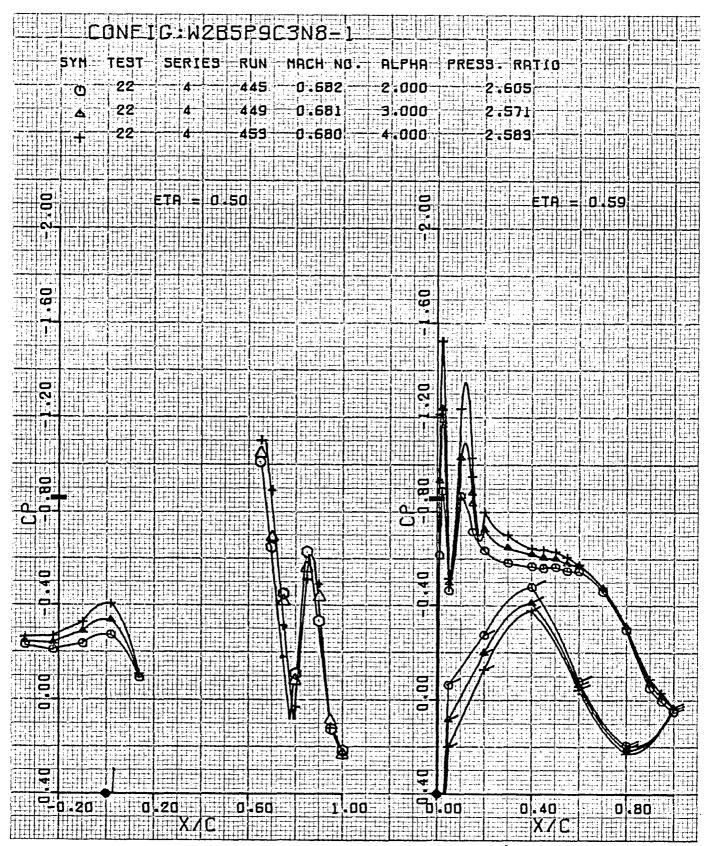


Figure 166. Wing pressure distribution, effect of α , nozzle N_8^1 , $M_{\infty} = 0.68$, $\eta = 0.50$, 0.59

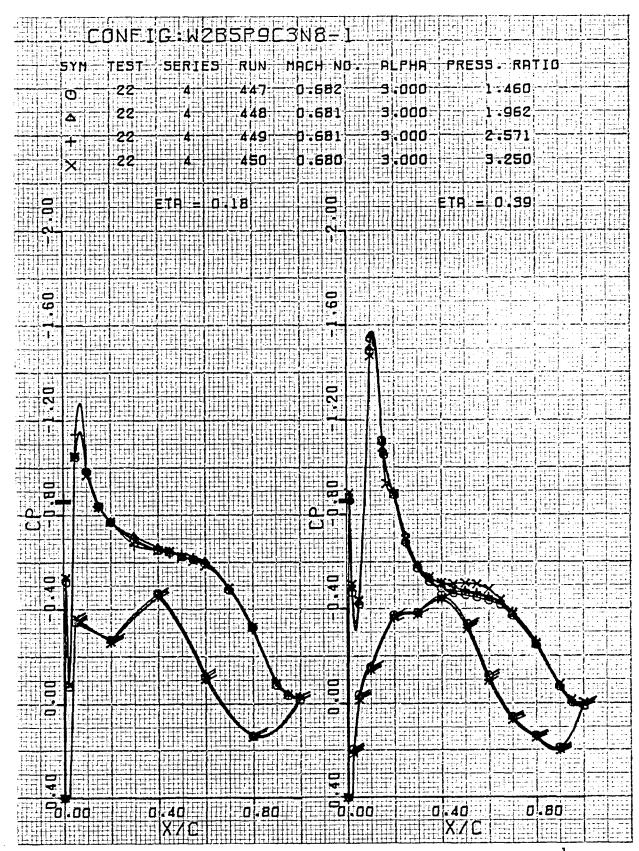


Figure 167. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N_8^{-1} , $M_\infty = 0.68$, $\eta = 0.18$, 0.39

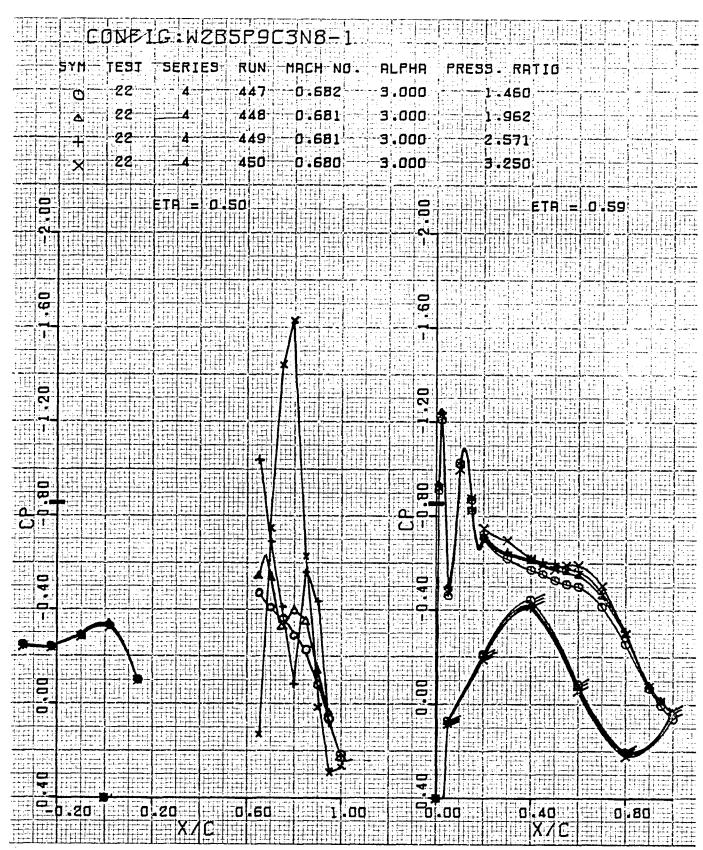


Figure 168. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N_8^1 , $M_{\infty} = 0.68$, $\eta = 0.50$, 0.59

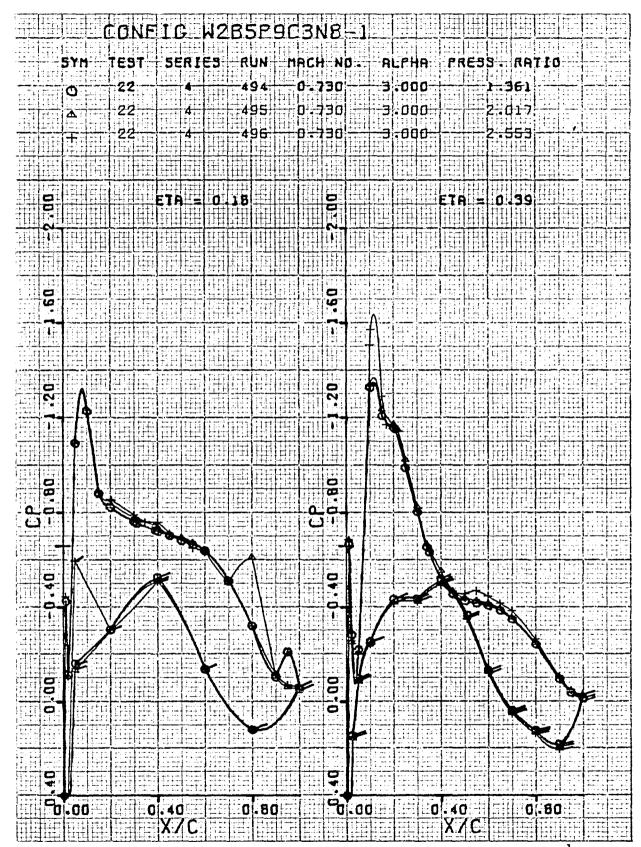


Figure 169. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N_8^{-1} , $M_\infty = 0.73$, $\eta = 0.18$, 0.39

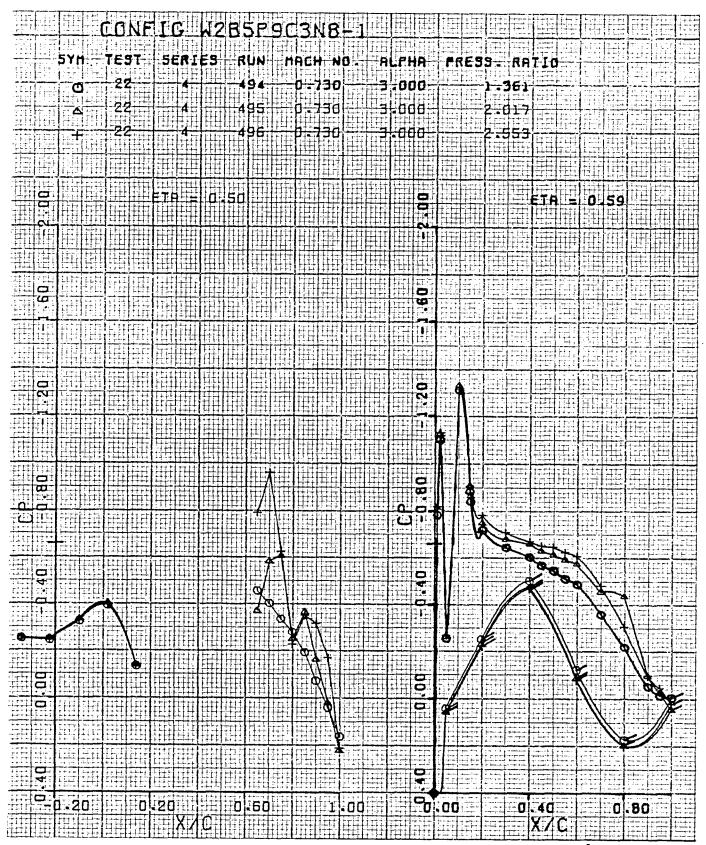


Figure 170. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N_8^1 , $M_{\infty} = 0.73$, $\eta = 0.50$, 0.59

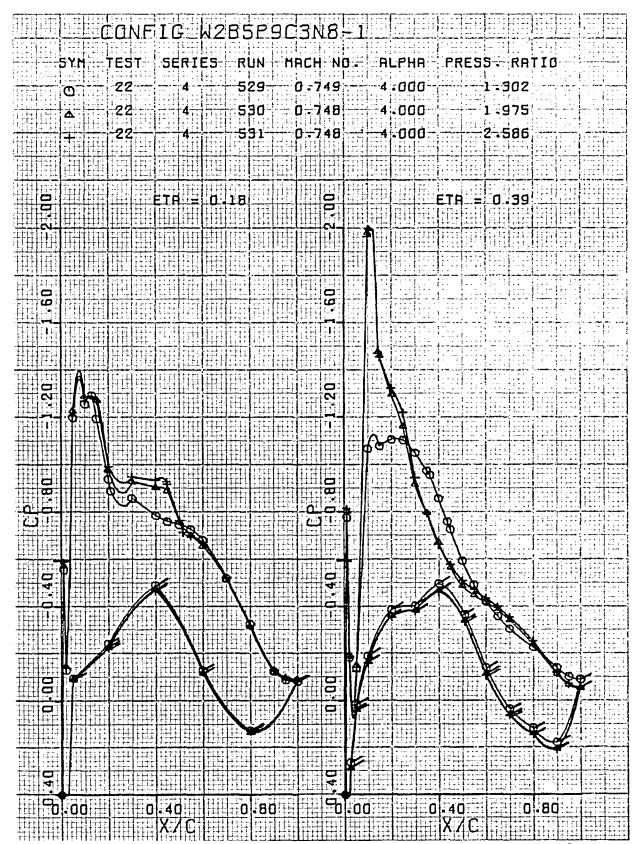


Figure 171. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N_8^{-1} , $M_{\infty}=0.75$, $\eta=0.18$, 0.39

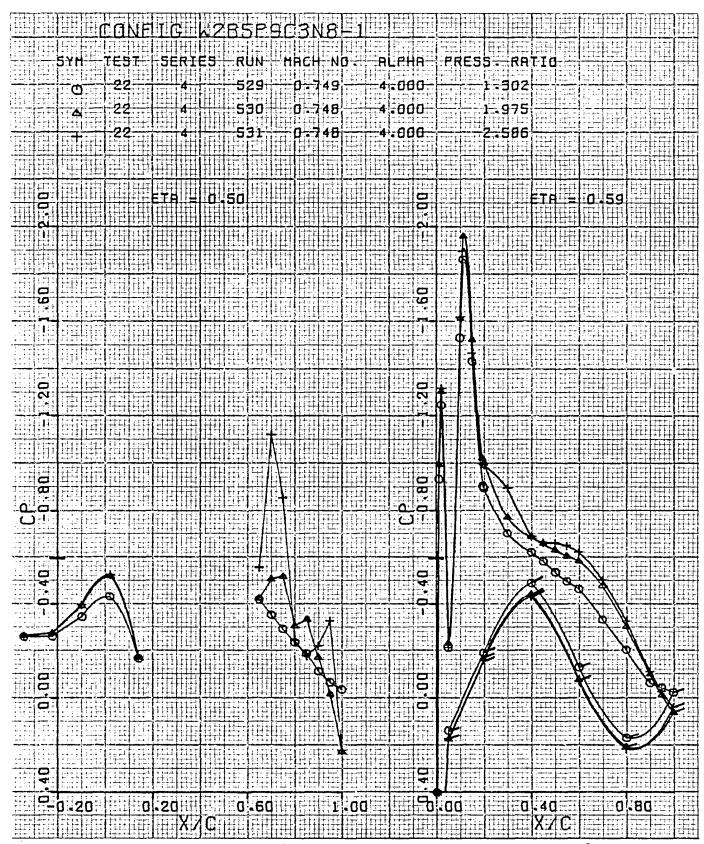


Figure 172. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N_8^{-1} , $M_{\infty} = 0.75$, $\eta = 0.50$, 0.59

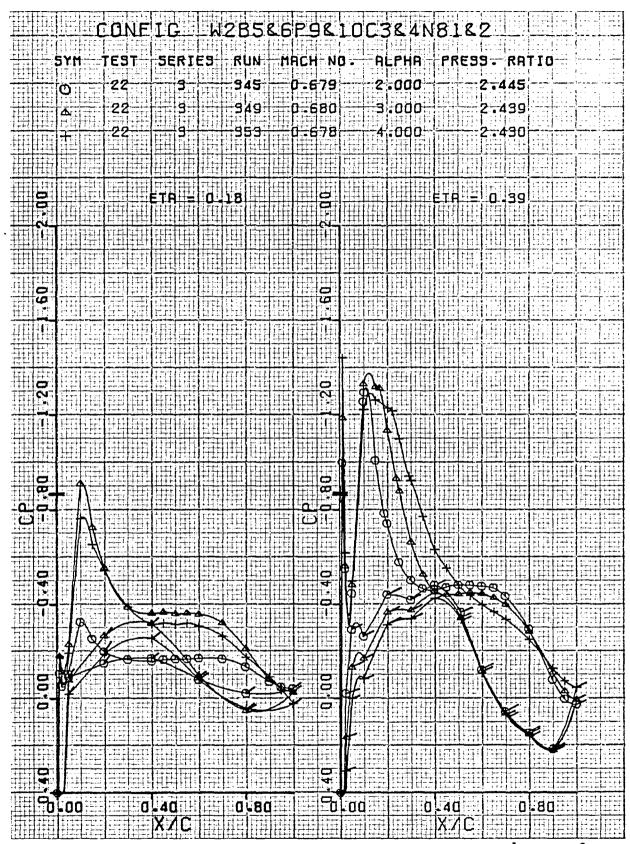


Figure 173. Wing pressure distribution, effect of α , nozzles N_8^{-1} and N_8^{-2} , $M_{\infty} = 0.68$, $\eta = 0.18$, 0.39

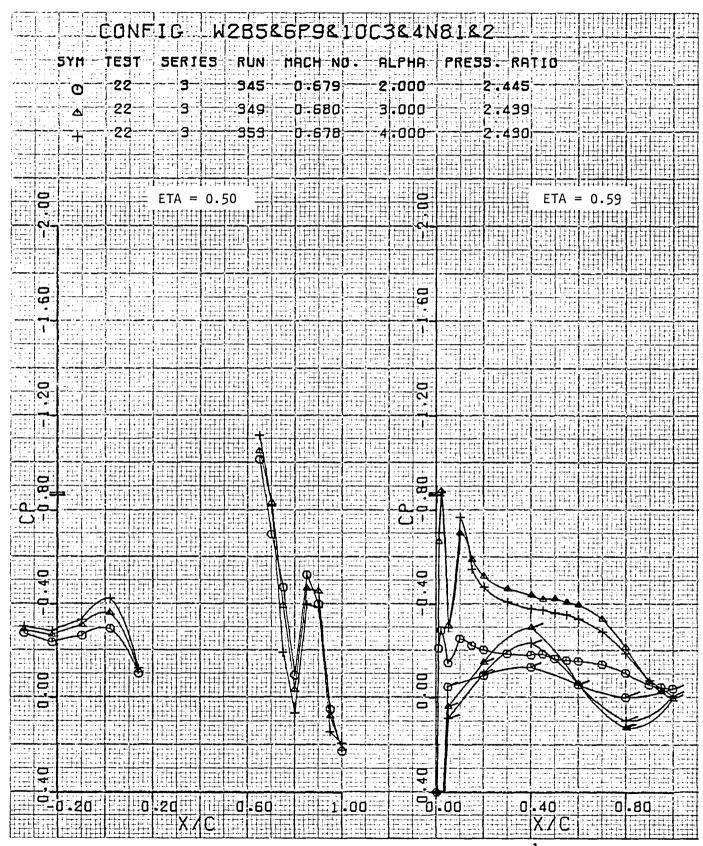


Figure 174. Wing pressure distribution, effect of α , nozzles N_8^{-1} and N_8^{-2} , $M_{\infty} = 0.68$, $\eta = 0.50$, 0.59

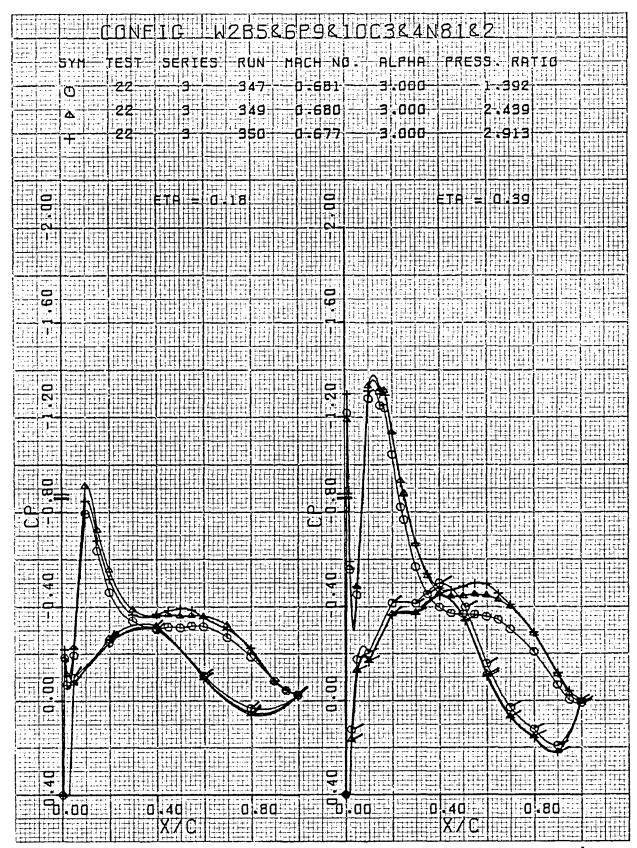


Figure 175. Wing pressure distribution, effect of nozzle pressure ratio, nozzles N_8^{-1} and N_8^{-2} , $M_\infty = 0.68$, $\eta = 0.18$, 0.39

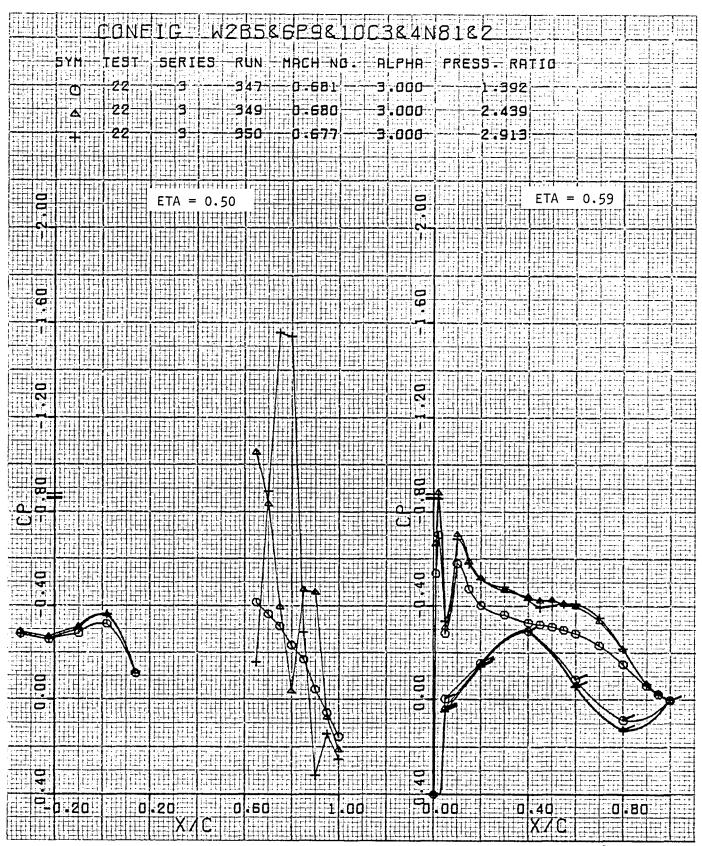


Figure 176. Wing pressure distribution, effect of nozzle pressure ratio, nozzles N_8^{-1} and N_8^{-2} , $M_\infty=0.68$, $N_8=0.50$, 0.59

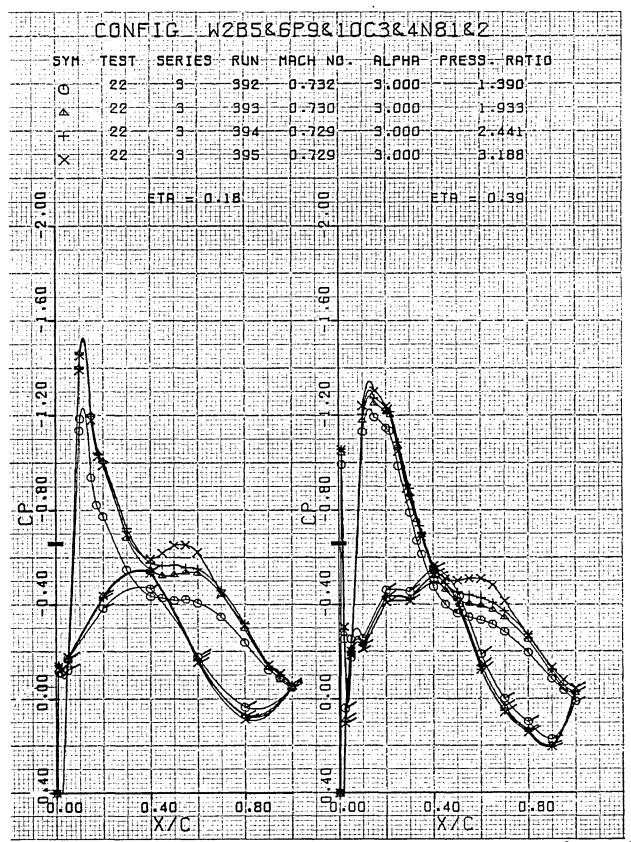


Figure 177. Wing pressure distribution, effect of nozzle pressure ratio, nozzles N_8^{-1} and N_8^{-2} $M_{\infty} = 0.73$, $\eta = 0.18$, 0.39

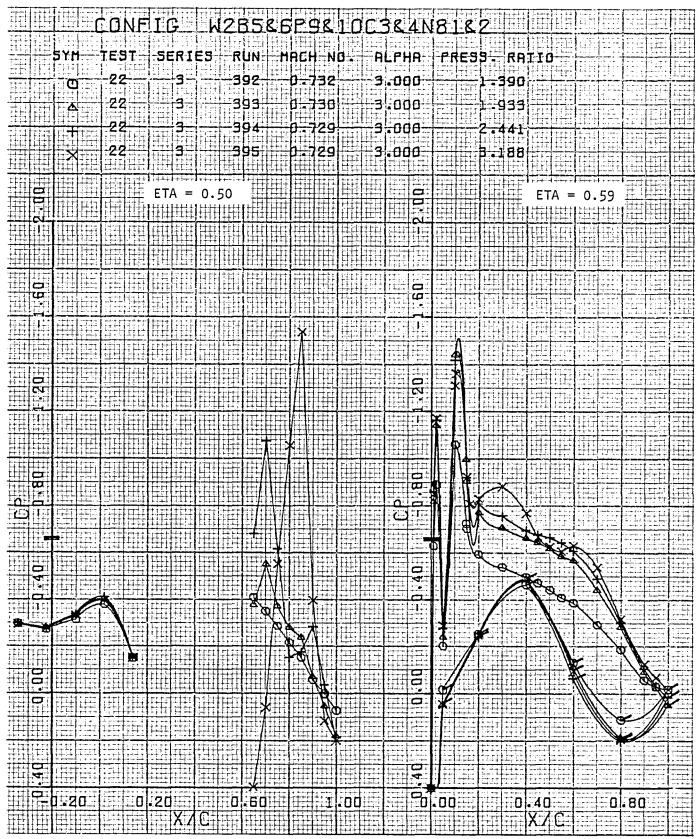


Figure 178. Wing pressure distribution, effect of nozzle pressure ratio, nozzles N_8^{-1} and N_8^{-2} , $M_{\infty} = 0.73$, $\eta = 0.50$, 0.59

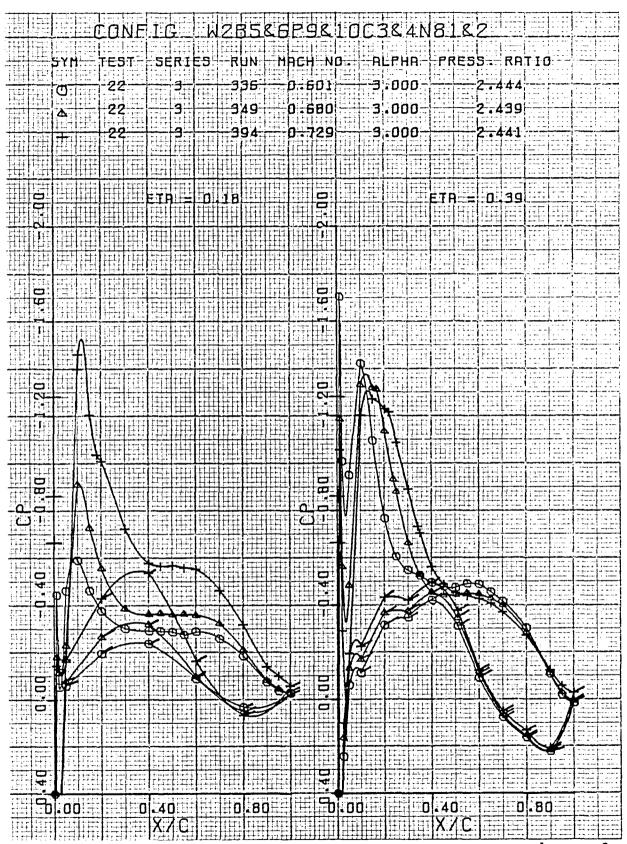


Figure 179. Wing pressure distribution, effect of Mach number, nozzles N_8^1 -and N_8^2 , $\eta = 0.18, 0.39$

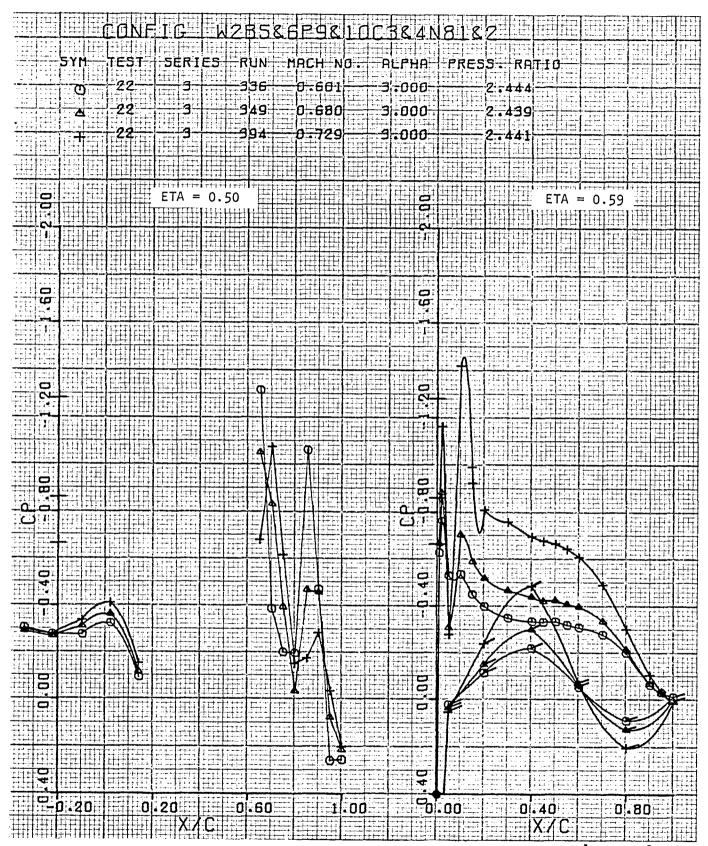


Figure 180. Wing pressure distribution, effect of Mach number, nozzles N_8^1 and N_8^2 , $\eta = 0.50, 0.59$

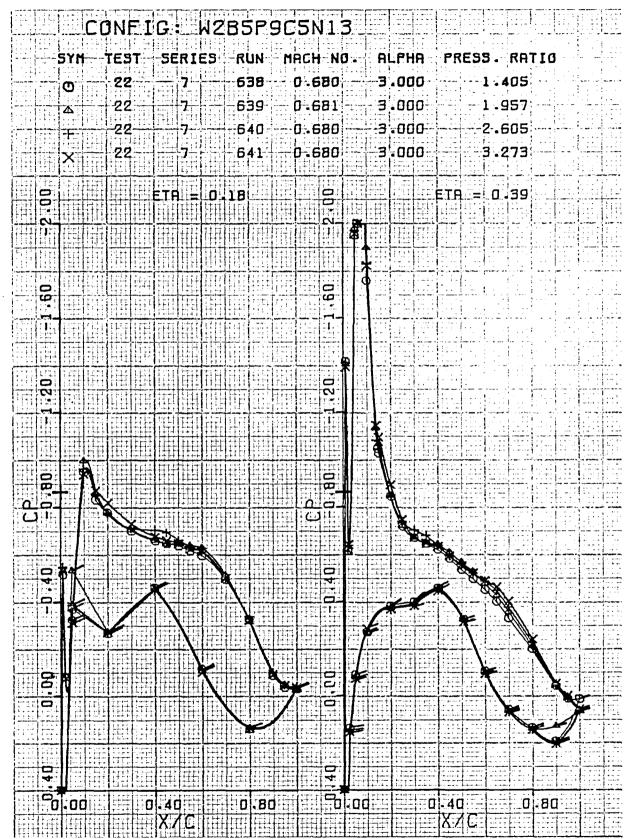
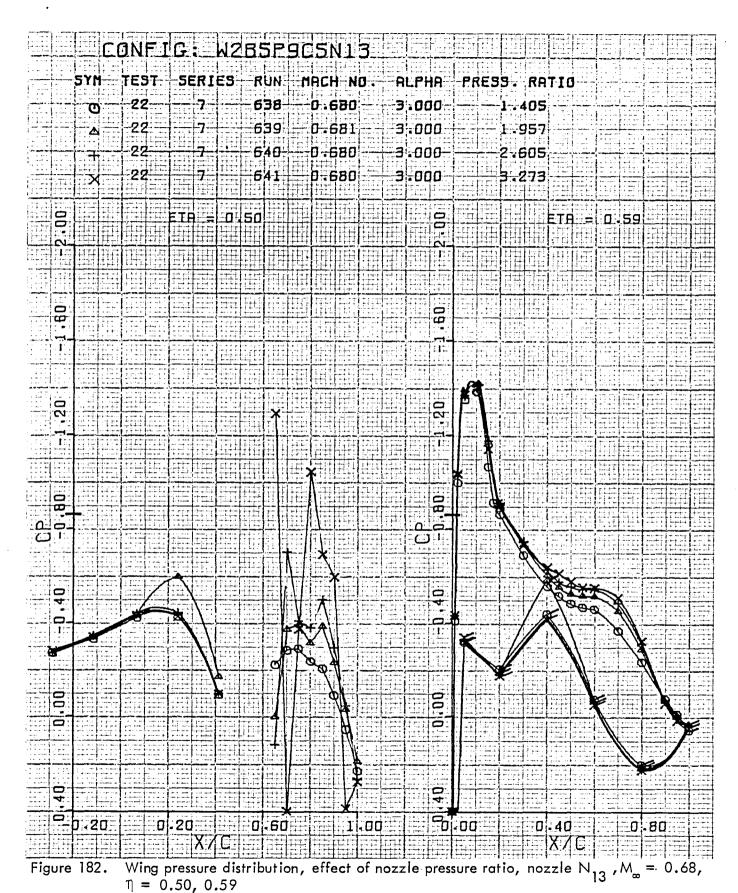


Figure 181. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N_{13} , $M_{\infty} = 0.68$, $\eta = 0.18$, 0.39



η = 0.30, 0.37

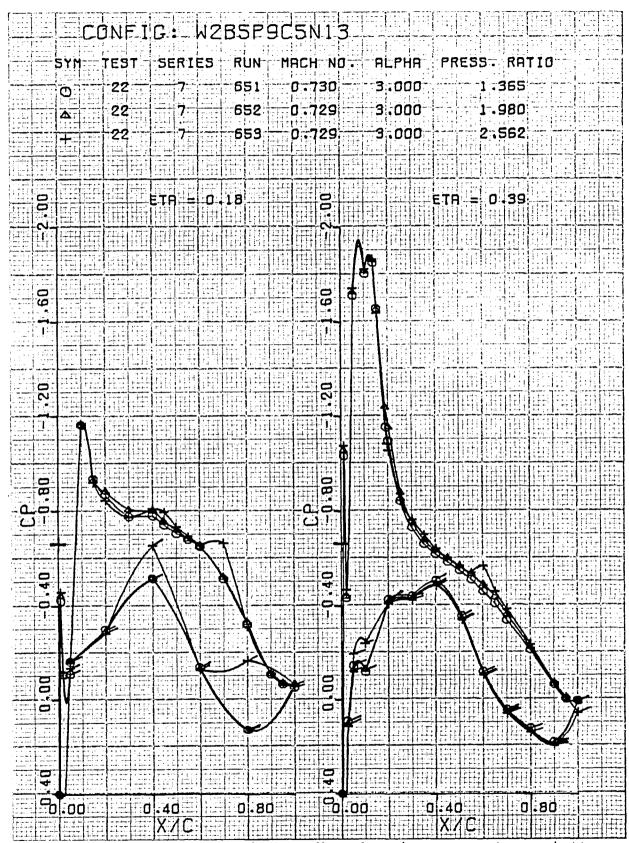


Figure 183. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N_{13} , $M_{\infty} = 0.73$, $\bar{\eta} = 0.18$, 0.39

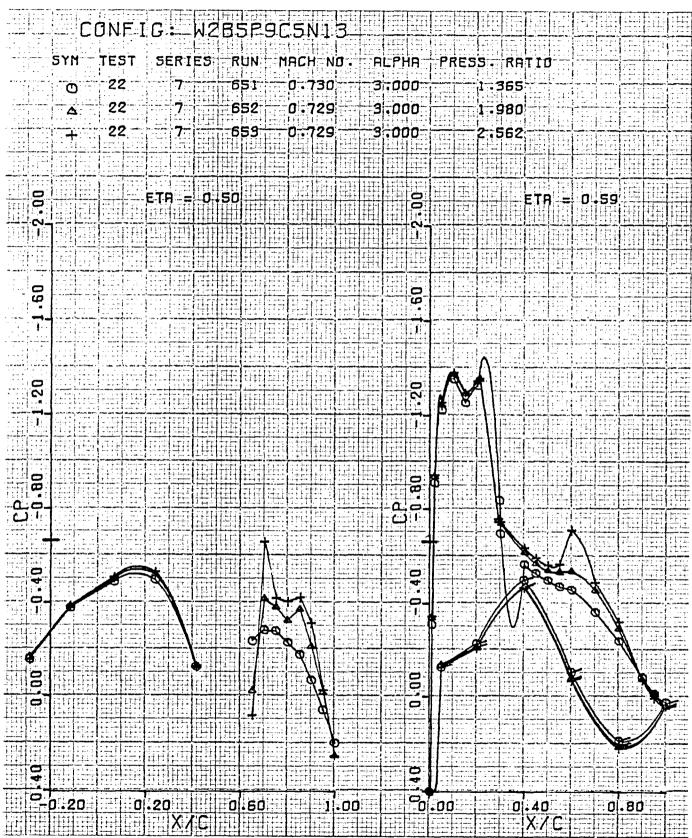


Figure 184. Wing pressure distribution, effect of nozzle pressure ratio, nozzle N_{13} , $M_{\infty} = 0.73$, $N_{\infty} = 0.50$, 0.59

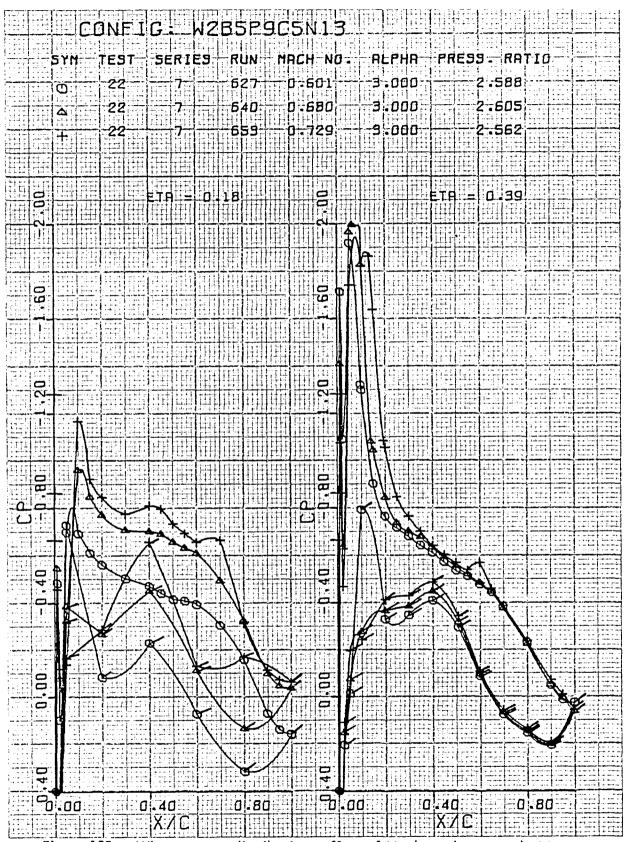


Figure 185. Wing pressure distribution, effect of Mach number, nozzle N_{13} , $\eta = 0.18, 0.39$

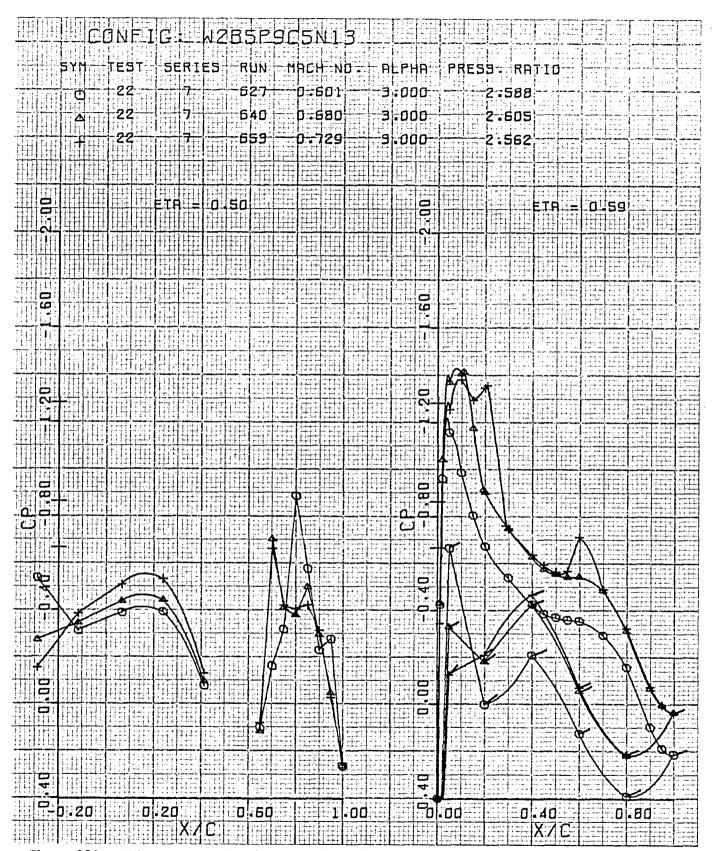


Figure 186. Wing pressure distribution, effect of Mach number, nozzle N_{13} , η = 0.50, 0.59

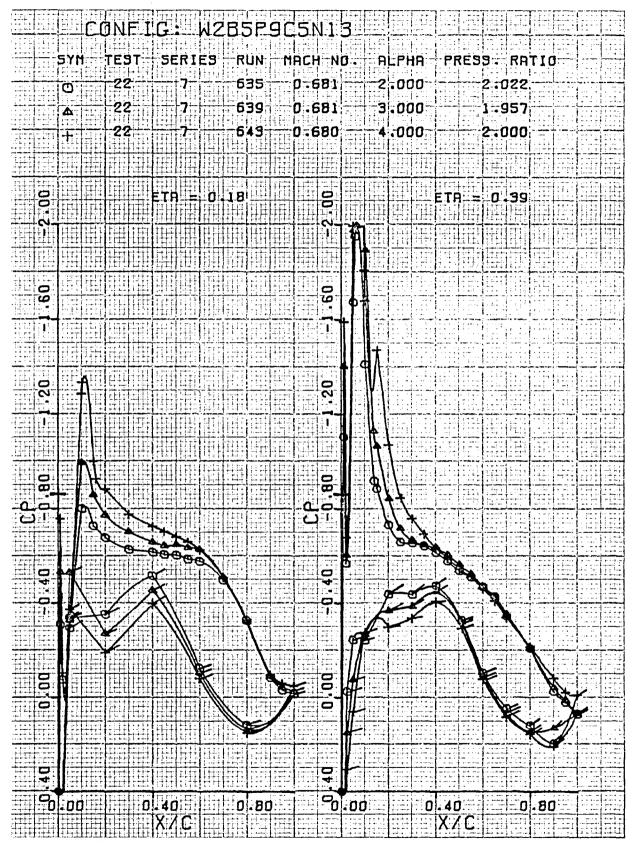
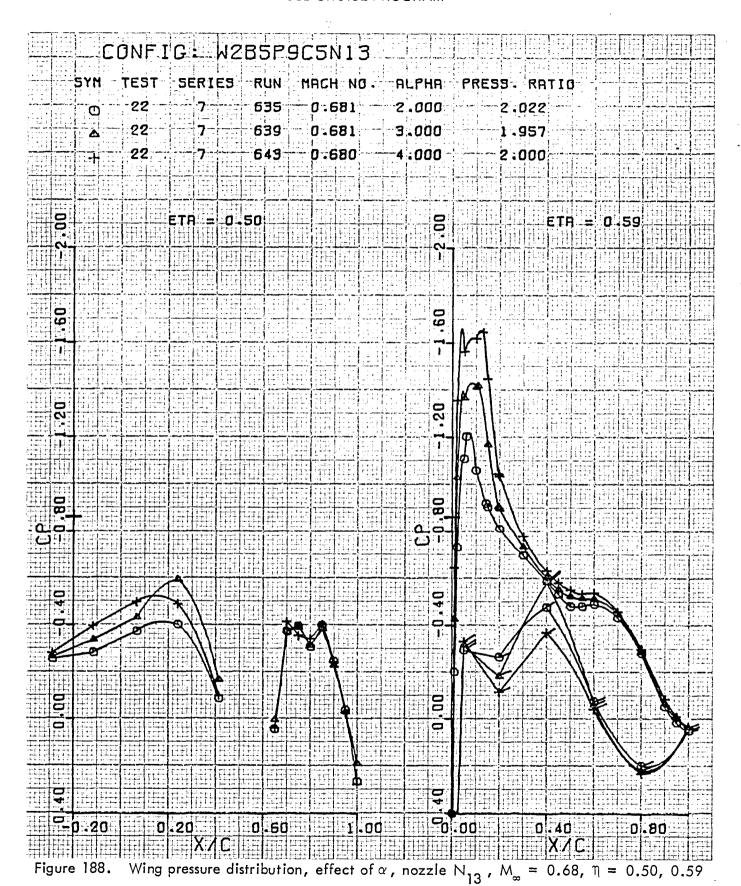


Figure 187. Wing pressure distribution, effect of α , nozzle N_{13} , $M_{\infty} = 0.68$, $\eta = 0.18$, 0.39



6.2 Wake Pressure Patterns

Isobars for selected swept wing configurations are presented in Figures 189 through 199. The format is identical to that employed for the straight wing isobars and the illustrative figure, 105, applies to this section also.

Model configurations for which wake patterns are presented are N_8^{-1} , N_8^{-2} , and N_{13}^{-1} .

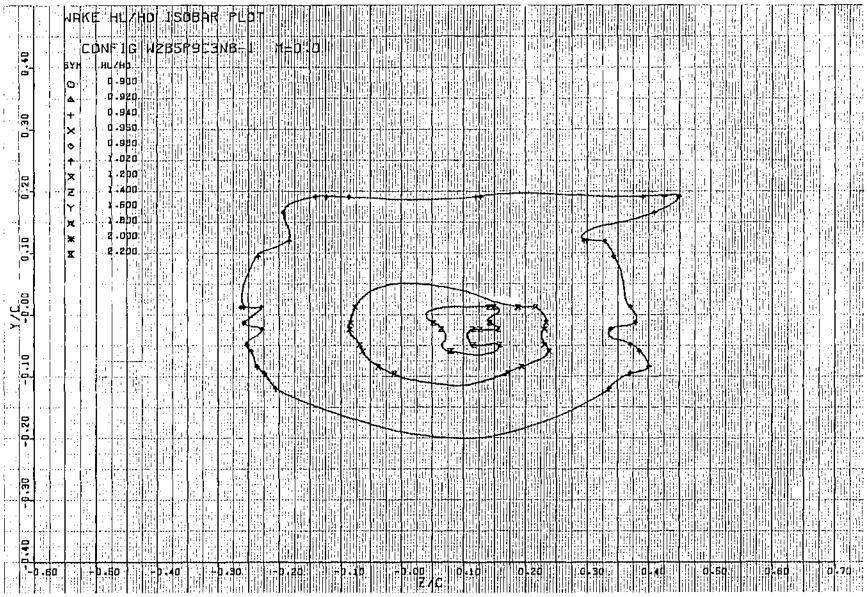
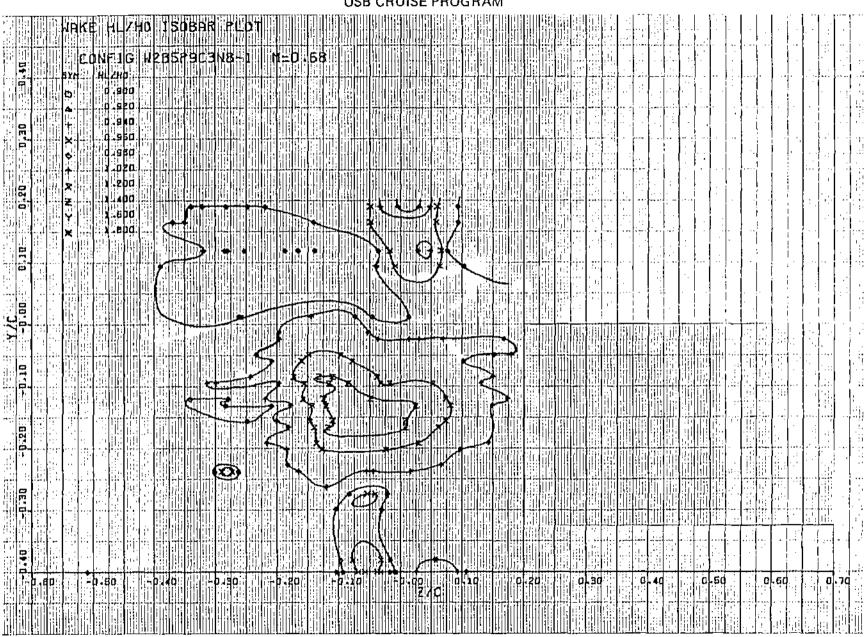


Figure 189. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$, test 22, series 4, run numbers 465 - 470, $\alpha = 3^\circ$



Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$, test 22, series 4, run numbers 475 – 489, $\alpha = 3^\circ$ Figure 190.

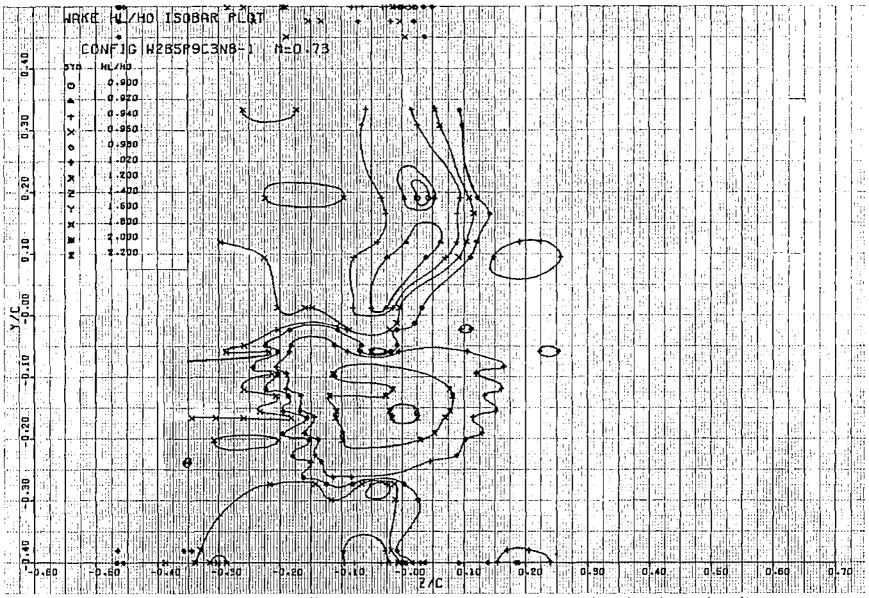
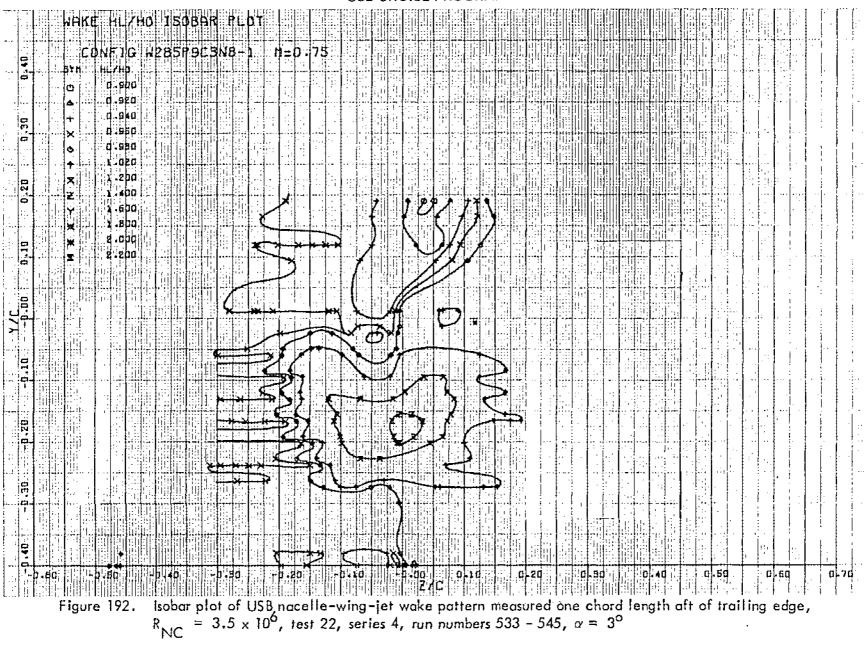


Figure 191. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6, \text{ test } 22, \text{ series } 4, \text{ run numbers } 502 - 515, \alpha = 3^0$



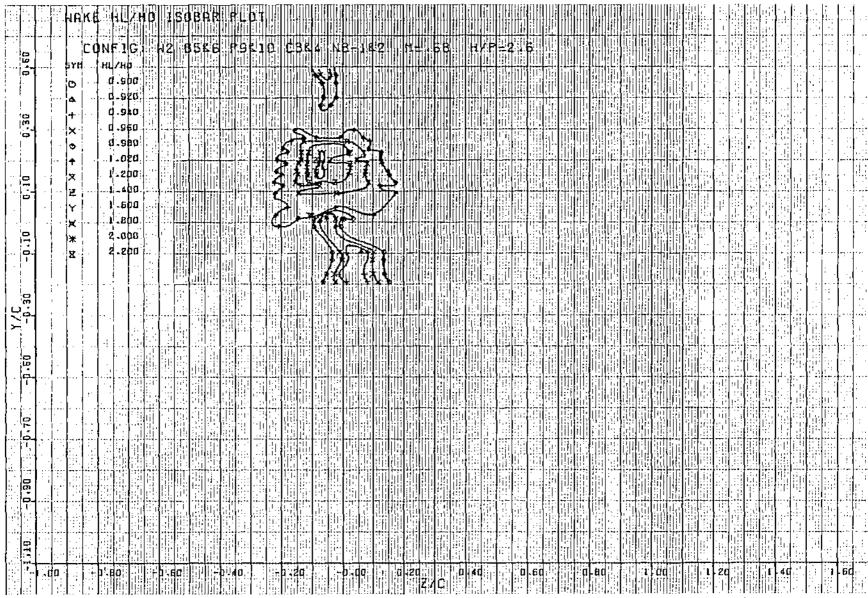


Figure 193. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$, test 22, series 3, run numbers 355 – 367, $\alpha = 3^9$

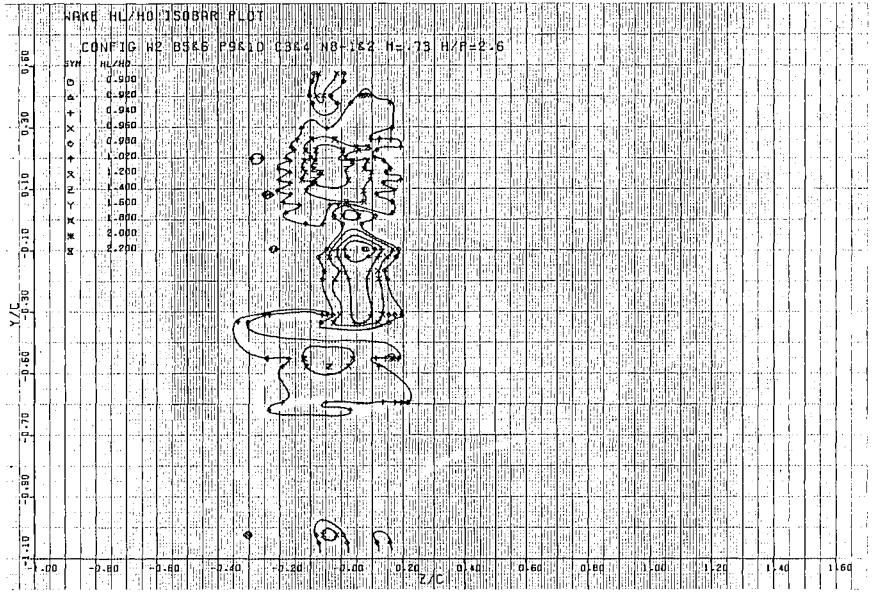


Figure 194. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$, test 22, series 3, run numbers 277 - 297, $\alpha = 3^\circ$

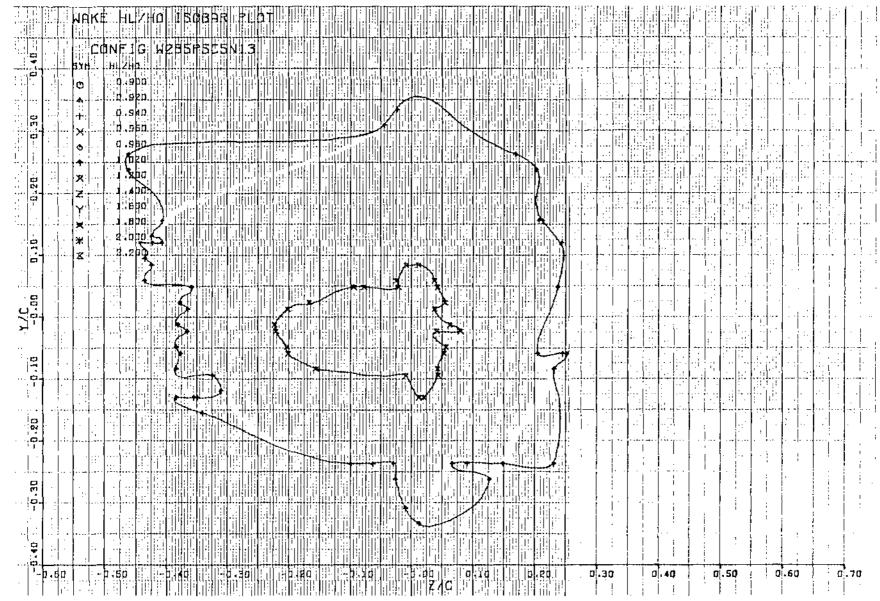


Figure 195. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$, test 22, series 7, run numbers 662 - 674, $\alpha = 0$, $M_{\infty} = 0$, $H_{1}/P_{\infty} = 2.70$

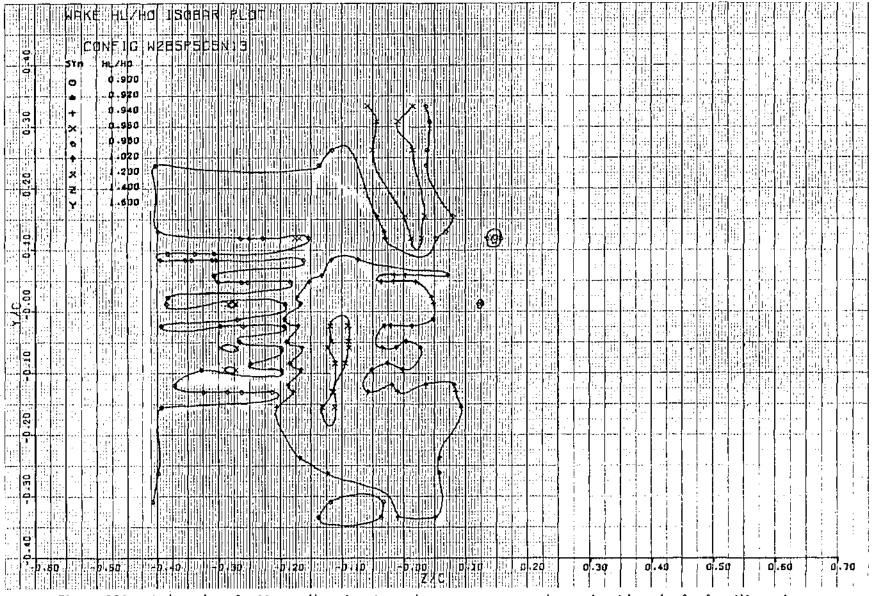


Figure 196. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^6$, test 22, series 7, run numbers 703 - 715, $\alpha = 3^\circ$, $M_{\infty} = 0.68$, H. $/p_{\infty} = 2.56$

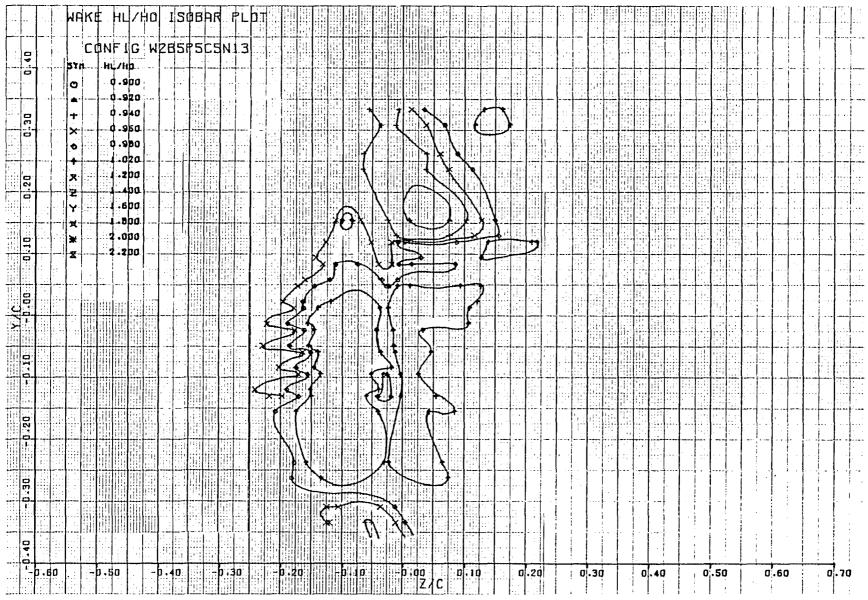


Figure 197. Isobar plot of USB nacelle-wing-jet wake pattern measured one chord length aft of trailing edge, $R_{NC} = 3.5 \times 10^{\circ}$, test 22, series 7, run numbers 690 - 702, $\alpha = 3^{\circ}$, $M_{\infty} = 0.73$, $H_{\infty}/p_{\infty} = 2.60$

7.0 REFERENCES

- 1. Braden, J. A., Hancock, J. P., and Hackett, J. E., "Exploratory Studies of the Cruise Performance of Upper-Surface Blown Configurations, Program Plan", Lockheed-Georgia Company, May 1., 1972.
- 2. Braden, J. A., Hancock, J. P., Burdges, K. P., and Hackett, J. E., "Exploratory Studies of the Cruise Performance of Upper Surface Blown Configuration, Experimental Program Test Facilities, Model Design, Instrumentation, and Low-Speed High-Lift Tests," NASA CR-3192, 1979.

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16. Abstract						
The present report provides basic pressure data obtained from an experimental study of upper-surface blown (USB) configurations at cruise. The high-speed (subsonic) experimental work, studying the aerodynamic effects of wing-nacelle geometric variations, was conducted around semi-span model configurations composed of diversified, interchangeable components. Power simulation was provided by high-pressure air ducted through closed forebody nacelles. Nozzle geometry was varied across size, exit aspect ratio, exit position and boattail angle. Both 3-D force and 2-D pressure measurements were obtained at cruise Mach numbers from 0.5 to 0.8 and at nozzle pressure ratios up to about 3.0. The experimental investigation was supported by an analytical synthesis of the system using a vortex lattice representation with first-order power effects. Results are also presented from a compatibility study in which a short-haul transport is designed on the basis of the aerodynamic findings in the experimental study as well as acoustical data obtained in a concurrent program. High-lift test data are used to substantiate the projected performance of the selected transport design.						
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